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SUBTOTAL GASTRECTOMY FOR GASTRIC ULCER: A STUDY OF END RESULTS*

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GASTRIC ULCER differs in a number of respects from duodenal ulcer, a lesion with which it is often discussed and even confused under the common term peptic ulcer. Gastric ulcer is characterized by certain features which are lacking in duodenal ulcer and which exert an important influence upon the management of the disease. These several peculiarities may be summarized briefly as follows: (1) the existence of ulcer, its exact location, size and other characteristics can be demonstrated by roentgenologic examinations and/or gastroscopy in a high percentage of cases; (2) the response to treatment may be very accurately followed and recorded by these same methods; (3) it is often closely mimicked by primary ulcerating carcinoma; (4) carcinomatous degeneration may occur as a late complication of an originally benign chronic gastric ulcer; (5) surgical intervention is required in a larger percentage of cases than in the case of duodenal ulcer; (6) practically all surgical procedures, including the simpler ones, will substantially reduce the gastric acidity; (7) the clinical results of operative treatment are better than in duodenal ulcer and (8) anastomotic ulcer is a rare complication following gastroenteric anastomoses for gastric ulcer.

While during recent years the mortality of all gastric operations and particularly that of resection has steadily declined until it has reached a reasonably satisfactory level, the differentiation of benign ulcers, malignant ulcers and ulcerating carcinomas, remains a vexing clinical problem and one which is far from a satisfactory solution at the present[1, 2] time. These difficulties in accurate differential diagnosis have prompted certain authors, notably Allen and Lahey[3] to take the position that gastric ulcer, unlike duodenal ulcer, is primarily a surgical problem and that, except in certain unusual circumstances, surgical treatment should be advised once the diagnosis is made. They believe that by such a plan fewer lives will be lost from operative deaths than will be the case when gastric cancers are treated medically under a mistaken diagnosis. Other writers, outstanding among whom is Heuer[4, 5] question the propriety of

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such a radical attitude and especially with regard to gastric resection. The objections usually raised are: (1) an operative mortality that is still appreciable; (2) the unsatisfactory clinical results with or without recurrent ulceration which are seen in the occasional patient, and (3) the late nutritional disturbances which are observed in some cases after subtotal gastrectomy.

In order to formulate a working policy in regard to this matter for our own use in the future, we have endeavored to answer some of these questions on the basis of our own past experience. The present studies, therefore, represent an attempt to: (1) ascertain the risk involved in operation and to some degree the incidence of malignant growth; (2) make a critical analysis of clinical end results as far as the ulcer problem is concerned, and (3) discover the incidence and severity of certain side-effects of the operation, such as post-resection symptoms, nutritional disturbances, blood disorders, etc.

CLINICAL MATERIAL

During the 20 years that have passed since the University Hospital received its first patient in late 1925, 1356 patients with gastric ulcer have been observed and treated on the medical and surgical services. Of this number, 246 patients or 18.9 per cent required surgical intervention. The incidence of surgical treatment during the last 3 years of this study (1943, 1944 and 1945) was just over 30 per cent. Twenty of these 246 patients exhibited acute perforations of a gastric ulcer and required emergency surgical therapy. Since, in such cases, the problem is unique and about it there is no difference of opinion, these 20 cases will not be considered further. Elective surgical procedures were performed in 226 cases. The yearly incidence of all gastric ulcers, as well as of those treated surgically by year, is outlined in Figure 1. This graph also illustrates an experience which has been common in all surgical clinics, *i.e.*, the decline in popularity of the more conservative operations such as gastroenterostomy and knife or cautery excision of the ulcer either singly or in combination, in favor of the more radical procedure of gastric resection. The latter procedure has, here as elsewhere, become the operation of choice in the treatment of gastric ulcer during these past 20 years when 188 partial, subtotal or total gastrectomies have been performed. Whether this procedure, while admittedly giving satisfactory results as far as cure of the ulcer is concerned, will remain the best one for the lesion under discussion, may be questioned by some in view of the dramatic results now being reported from vagal interruption for both gastric and duodenal ulceration. Certainly it is true that additional experience with this newer procedure will be required and a longer time interval for further observations will be necessary before a final evaluation can be made. In view of the ever-present danger of potential or existent carcinoma in ulcers proximal to the pyloric valve, it seems likely that subtotal gastrectomy will continue to hold an important position in the surgical field for the treatment of lesions in this location. In the meantime, it is well from time to time to assess the value of and consider the true worth of this operation in view of the evidence which has now accumulated. For that reason an intensive follow-up

survey of cases treated by gastrectomy during the past 20 years has been undertaken in order to consider the late end results. Some patients have been followed for as long as 20 years and a considerable number have been followed from the time of operation to their death from whatever cause many years later. Thus an overall survey is possible and certain more or less final conclusions can be drawn.

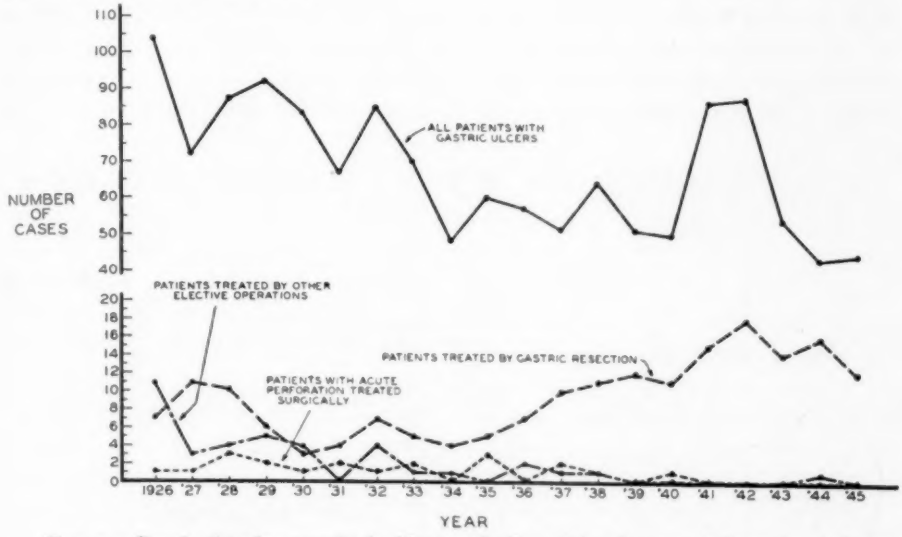
NUMBER OF CASES
ALL PATIENTS WITH GASTRIC ULCERS
PATIENTS TREATED BY OTHER ELECTIVE OPERATIONS
PATIENTS TREATED BY GASTRIC RESECTION
PATIENTS WITH ACUTE PERFORATION TREATED SURGICALLY
YEAR

FIG. 1.—Graph showing yearly incidence of all gastric ulcers and those treated surgically. Surgical treatment was carried out in 18.9 per cent of the entire group (including acute perforations) and in 30.5 per cent (all elective operations) during the last three years.

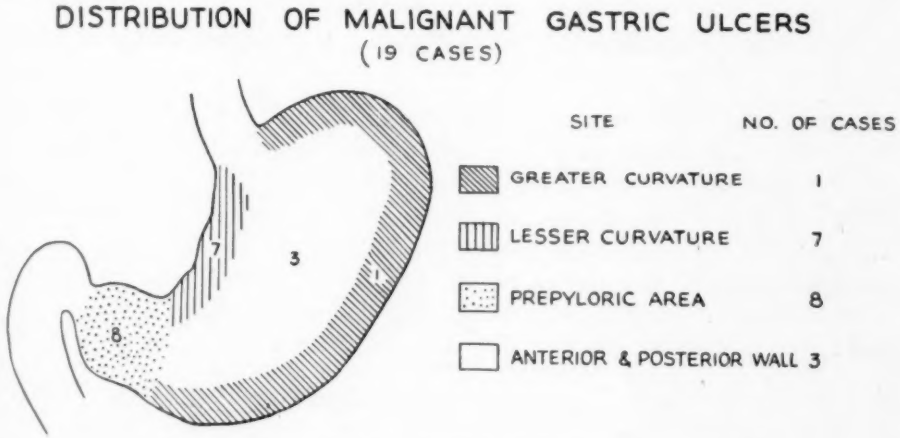

FIG. 2.—Diagram showing location of 19 "malignant ulcers."

The group of 188 patients under consideration consisted of 154 men and 34 women whose ages range from 29 to 74 years, the average age being 52.3 years. In all cases, with the exception of one, in which a palliative gastrectomy[6, 7] was performed, the ulcer was removed at operation and subsequently

investigated by histologic study. While in many cases the preoperative diagnosis was that of possible malignancy, in all cases at operation it was the opinion of the operator that he was dealing with a benign lesion, as no unusual features which led him to suspect malignancy were noted in either the lesion itself or the regional lymph nodes. Accordingly the usual type of ulcer resection was carried out without resorting to wide removal of omenta or lymph node bearing areas. Moreover gross examination of the surgical specimen in no case revealed conclusive evidence of malignancy. In the last analysis, however, as the result of microscopical studies, 19 patients or 10.1 per cent were found to have malignant disease superimposed upon an old chronic ulcer. The

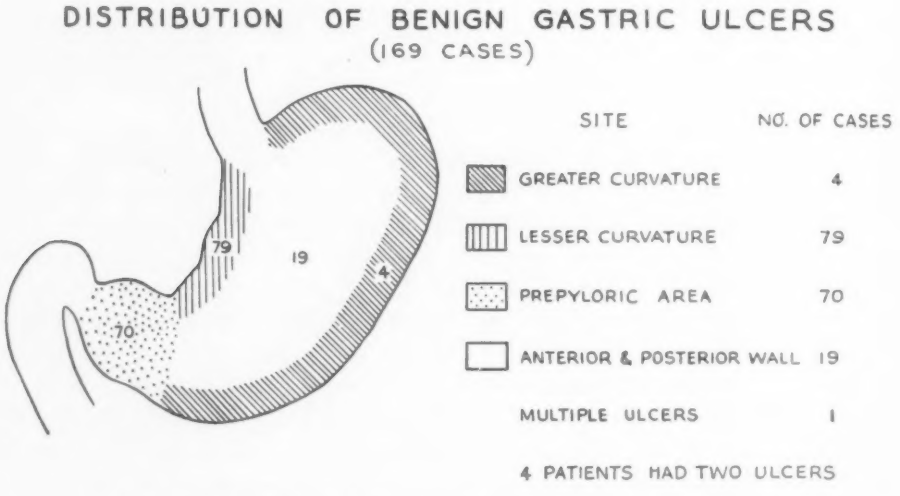

FIG. 3.—Diagram showing location of 169 benign gastric ulcers.

location of these malignant ulcers is shown in Figure 1. In all of the remaining 168 cases, the diagnosis of a benign ulcer was confirmed by the pathologist. The location of the benign ulcers is shown in Figure 2. Four patients had two independent and coexistent gastric ulcers, while in one case there were multiple ulcers of the stomach and duodenum. In 31 of the 188 cases an associated duodenal ulcer, either active or healed, was also present as noted at the time of operation. In every case, however, this lesion was of secondary importance and the behavior of the gastric ulcer governed the treatment of the patient.

INDICATIONS FOR OPERATION

During the 20-year period under discussion a conservative attitude in treatment has been shared by members of both the medical and surgical departments as far as peptic ulcer is concerned and relatively few patients have been advised to have surgical therapy unless there was convincing proof as the result of a fair trial of thorough medical treatment that no other measures would suffice. In Table I the original indications for surgical intervention in these

TABLE I

GASTRIC RESECTION FOR GASTRIC ULCER
INDICATIONS FOR SURGERY

Chief Indication	No. of Cases	Per Cent
Intractable to Conservative Treatment	69	36.7
Probable Carcinoma	56	29.8
Obstruction	41	21.8
Penetrating ulcer	10	5.3
Hemorrhage	9	4.8
? Perforation	3	1.6
Total	188	100.0

188 cases are summarized. Although frequently there were several factors which combined to indicate surgery, for the sake of simplicity the most important one has been selected for this tabulation. While in practically all cases the possibility of malignancy was present in 56 cases or 29.8 per cent a clinical diagnosis of probable carcinoma was made on the basis of all of the data available. This diagnosis was entertained in view of the age of the patient, the short clinical history, achlorhydria, roentgen studies and gastroscopy, considered either singly or in combination. In five instances large ulcers on the greater curvature of the stomach strongly suggested a malignant lesion and in others the prepyloric location increased the likelihood of malignancy since Holmes and Hampton[8] have found 65 per cent of prepyloric ulcerating lesions to be malignant. The largest group, *i.e.*, 69 patients or 36.7 per cent, were proven beyond peradventure of a doubt to have lesions quite intractable to conservative measures. These ulcers failed to heal or to remain healed or as not infrequently happened actually increased in size while a strict medical regimen was in progress. They were, therefore, necessarily regarded as malignant ulcerations or calloused benign ulcers which could not be closed by conservative measures and accordingly surgery was in order. Persistent obstruction failing to yield to conservative means was largely responsible for the necessity of surgical intervention in 41 patients or 21.8 per cent of the group. Repeated bouts of alarming hemorrhage required surgical therapy in 9 cases or 4.8 per cent and in a considerable number of other patients bleeding was an important item in the clinical history. There were no instances in this series of emergency surgery for acute massive hemorrhage. In three cases operation was performed during an episode of acute abdominal symptoms which strongly suggested an acute perforation. An incorrect diagnosis was proven at laparotomy, at which time, however, resection was performed. In ten cases the fact that roentgenograms showed evidence of a deeply penetrating ulcer constituted the indication for surgery. In summary, it may be said that in almost every case in which operation was performed malignancy could not be positively excluded and, if for no other reason, the operation was justified on the assumption that that particular lesion was a possible or probable carcinoma.

A summary of the status of the medical program, prior to operation, is given in Table II. It will be observed that exactly one-half of these cases

TABLE II

GASTRIC RESECTION FOR GASTRIC ULCER
STATUS OF MEDICAL TREATMENT

Character of Treatment	No. of Cases	Per Cent
Adequate or intensive. In hospital	95	50.5
None	53	28.2
Brief	29	15.4
None. Much elsewhere	11	5.9
Total	188	100.0

received an intensive course of medical management in the hospital before being advised to accept surgical treatment. In all of these cases the evidence was convincing that further attempts at conservative therapy would be useless. Eleven patients or 5.9 per cent were referred by their home physicians for surgery. They had all received good medical management by their physicians before coming to the hospital and for them any further attempt at medical treatment was thought superfluous. Because of the strong presumptive evidence of malignant disease, surgical treatment was carried out at once in 53 cases or 28.2 per cent. Twenty-nine patients or 15.4 per cent were given a trial of conservative treatment but when because of persistent obstruction, continued bleeding or constant pain it became apparent such treatment would not succeed, surgery was undertaken at an early date.

TYPE OF OPERATION

In Table III the several types of operation which were performed in the 188 cases are listed. During the past decade our preference has been for the

TABLE III

TYPE OF OPERATION—188 CASES

Operation		No. of Cases
Polya		
Antecolic	3	
Retrocolic	44	47
Hoffmeister		
Antecolic	15	
Retrocolic	113	128
Finsterer		6
Finsterer (?)		2
Finsterer-Bancroft		1
Palliative gastrectomy		1
Total gastrectomy		3

Hoffmeister type of reconstruction with a retrocolic anastomosis if and when technically feasible. Partial closure of the cut end of the gastric pouch has seemed to reduce the incidence of malfunctioning stomas during the early postoperative period and to avoid too rapid emptying of the stomach later. The removal of practically all of the lesser curvature, a desideratum in the treatment of peptic ulcer, especially when duodenal ulcer is present, is likewise facilitated. In the first decade from 1926 to 1936 the posterior Polya reconstruction was the procedure most often employed.

Total gastrectomy was performed in three cases in all of which the ulcer was situated high on the lesser curvature or on the posterior wall and had proven quite intractable under most intensive medical treatment. The radical complete gastrectomy was elected at the time of laparotomy in the belief that the lesion must be malignant, whereas subsequent microscopic studies in all three cases revealed it to be benign. With the mortality of total gastrectomy still relatively high and with the higher incidence of post-resection symptoms, it is questionable whether total gastrectomy should often be performed for benign ulcer. In the future, for such lesions, we would suggest excision of the ulcer in order to have tissue for microscopical examination, in combination with vagotomy and with or without a complementary gastric drainage operation. A second alternative is the transthoracic resection of the upper portion of the stomach as suggested by Sweet.[9]

Palliative gastrectomy as recommended by Colp was performed in only one case. This patient had a large gastric ulcer high on the lesser curvature and also an old duodenal ulcer which made the dissection of the upper portion of the duodenum a tedious and time-consuming task. In order to avoid the risk of an exceptionally high sub-total or even total resection, the ulcer containing segment of the duodenum and the lower two-thirds of the stomach were resected leaving the gastric ulcer *in situ*.

Finsterer's[10] resection for exclusion as usually performed for very active duodenal ulcers has been followed by a high incidence of stomal ulcer in the experience of practically all surgeons and has now generally been discarded. Six such Finsterer procedures were noted in this series. All of these operations were performed in the early years when the importance of elimination of all of the antral mucous membrane was not fully appreciated. In all cases the gastric ulcer was removed, but this procedure was elected when inflammation about the pylorus would have made a dissection beyond it dangerous and the closure of the duodenal stump difficult and uncertain. It would seem from a perusal of the operative notes in two additional cases that the lower transection was just proximal to the pylorus and that the operation which was performed was probably a form of the Finsterer exclusion operation. Presumably this prepyloric transection was used in order to expedite the operation in that particular case. In one instance in which the Finsterer type of resection was intentionally performed, the mucosa of the antral segment was carefully dissected out and removed as suggested by Bancroft.[11]

OPERATIVE MORTALITY AND POSTOPERATIVE COMPLICATIONS

There were 15 operative deaths in the aforementioned 188 resections—a mortality of 7.9 per cent. The causes of death are listed in Table IV. In gastrectomy as in all other operations of similar magnitude, the mortality has decreased steadily during recent years. Better preoperative and postoperative care as well as the better methods of anesthesia now available, have been responsible for increased experience with the operation and standardization of the technic. It will be noted that pneumonia was the largest single contributor

TABLE IV

GASTRIC RESECTION FOR GASTRIC ULCER—188 CASES
Operative Deaths—15 Mortality—7.9 Per Cent

Cause of Death	Cases With Autopsy—8	Cases Without Autopsy—7
Pneumonia	3	1
General peritonitis—leak at gastro-enteric anastomosis	3	
Pancreatic fat necrosis	1	
Volvulus of afferent limb of jejunum. Peritonitis	1	
Wound disruption		1
Uremia		2
Shock		2
Acute vascular accident (pulmonary embolism or coronary thrombosis)		1

to the operative mortality, as four patients or over one-quarter of the group died from that complication. With the advent of chemotherapy and the antibiotic agents, this menace to success has been substantially reduced. The three deaths due to general peritonitis, all of which were the result of a leaking suture line, of course represent surgical errors, whereas the case of pancreatic fat necrosis and the one of volvulus of the jejunum are examples of surgical accidents possibly unavoidable but nevertheless regrettable. The volvulus of the jejunum occurred in a total gastrectomy in the proximal limb used for the anastomosis in a reconstruction after the method of Roscoe Graham.[12] Two cases are listed as dying of uremia. Since autopsies were not performed it is possible that peritonitis was primary with secondary renal suppression. In one of these cases a nephrectomy had been performed previously and here renal insufficiency is more probable. Likewise, in the two patients recorded as dying of surgical shock, autopsies were not permitted. Both patients died a few hours after return from the operating room and, since there was nothing unusual about their particular lesions and no complications had arisen during the operative procedure, they perhaps may be best classified as anesthetic deaths.

In making a final appraisal of the end results of gastric resection in the treatment of ulcer, not only must the clinical results over a number of years be considered but also the primary operative mortality. Our overall mortality rate of 7.9 per cent seems high at the present time and as such would serve as an indictment against the procedure. However, it must be borne in mind that most of these deaths occurred prior to 1936 and that the mortality has been greatly reduced in recent years. Many personal series composed of private patients would show a considerably lower death rate.

Table V gives the non-fatal postoperative complications, 64 such complications having been observed among 53 patients. It will be noted that major or minor wound sepsis constituted the largest group. These wound infections ranged from stitch abscesses to three cases of disruption in which a secondary operation for closure was required. It will be noted by referring to Table IV that in one case wound disruption was responsible for a fatal outcome, thus forcibly emphasizing the fact that disruption remains a serious complication

and carries a high death rate. Pulmonary complications occurred with disturbing frequency as there were 13 cases of bronchopneumonia, 8 of atelectasis and 1 of lung abscess. The latter lesion was post-pneumonic in origin. In recent years pulmonary complications have been reduced in frequency and severity by virtue of chemotherapy, early ambulation, better management of abdominal distention, improved anesthesia, tracheo-bronchial suction and aspiration bronchoscopy. In the two cases of postoperative intestinal fistula, fortunately, both closed spontaneously. They indicated either leakage at the anastomosis or more probably a small blow-out of the duodenal stump. The single example of a subdiaphragmatic abscess probably occurred by the same mechanism. The case of sulfonamide hepatitis occurred at a time when large quantities of sulfanilamide powder or crystals were introduced into the peritoneal cavity at the time of laparotomy as a prophylactic measure. In this case

TABLE V

GASTRIC RESECTION FOR GASTRIC ULCER
NON-FATAL POST OPERATIVE COMPLICATIONS
(64 complications among 53 patients)

Complication	No. of Cases
Wound sepsis	17
Broncho-pneumonia	13
Urinary tract infection	10
Pulmonary atelectasis	8
Wound dehiscence	3
Ileus	3
Intestinal fistula	2
Auricular fibrillation	2
Subphrenic abscess	1
Lung abscess	1
Cerebral hemorrhage	1
Thrombophlebitis	1
Abortion	1
Sulfonamide hepatitis	1

there was intense jaundice but spontaneous recovery took place without sequelae. The other complications for the most part occurred singly and were not serious. Urinary tract infections were fairly frequent but fortunately all terminated promptly under appropriate therapy.

MALIGNANT ULCERS

In 19 cases or 10.1 per cent the microscopical examination of the operative specimen disclosed unmistakable evidence of malignant disease. In none of these cases was suspicion sufficiently aroused at the time of operation to alter the course of the operative procedure and the usual ulcer resection was performed. The operative notes in these cases indicate findings identical with those of the lesions microscopically benign, and in none of these cases were the regional lymphnodes found noteworthy and accordingly extensive resection of lymphnode-bearing areas or omentumectomy were not performed. In 17 of the 19 cases microscopical study revealed an early or even advanced carcinoma developing on the basis of an old chronic peptic ulcer. In all of these cases the original lesion was definitely an ulcer with the carcinoma

superimposed and none were primary ulcerating carcinomas. Two cases showed at the edge of a chronic ulcer an area of lymphosarcoma. In this group of 19 patients with associated malignant disease, there were 15 men and 4 women. The two lymphosarcoma cases occurred in male patients. The age range for this group was 30 to 67 years, with an average of 56 years. This average age is slightly higher than that for the entire group which was 52.3 years or for the group of 169 benign lesions where it was 52.2 years. In 12 of the ulcer-cancer cases special studies of the regional lymphnodes attached to the operative specimen were made. In four there was involvement by metastatic carcinoma while in eight the nodes were negative. The regional lymphnodes in one of the lymphosarcoma cases revealed evidence of neoplasm. In view of the ultimate diagnosis of malignancy in this group, it is interesting to reconsider the status of the preliminary medical program. Three patients had had prolonged and intensive medical treatment elsewhere before entering the hospital and surgery was advised at once. In 9 cases there was no delay and for one reason or another prompt surgical intervention was recommended, whereas in 7 cases considerable valuable time was spent in unsuccessful medical treatment by us, and surgery was performed only when check-up roentgenograms showed failure of the ulcer to improve. There was one operative death in this group which has already been referred to as an anesthetic death.

The follow-up studies in this group are of special interest (Table VI). In addition to the patient who died in the hospital, another patient, a woman, returned as an emergency exactly one month after her discharge and required a tracheotomy for upper respiratory tract obstruction due to necrosis of the cricoid cartilage. This lesion was undoubtedly due to the prolonged use of a Levine tube for Wangensteen suction during the postoperative period. She died shortly after her return from the operating room. In addition to these two cases, six other patients have since died. All six with one exception have died of recurrent carcinoma. This latter patient survived for seven years and eight months free from recurrence and in good health and died of a cerebral hemorrhage. The survival period of the patients who died of malignant disease (excluding the one operative and the one early postoperative death) ranged from seven months to three years and seven months, the average being 24.6 months. Eleven patients of this malignant group are still living, their survival periods ranging from one year to seven years and ten months. All of them are in good health at the time of this report with one exception. This patient reports that his health is poor but in view of the fact that he has survived for six years and six months recurrence seems improbable. The two lymphosarcoma patients are both living and in good health at the present time.

In summarizing this group of 19 patients with microscopically verified malignancy associated with a chronic gastric ulcer, 7 or 36.9 per cent have now survived for more than five years; but if the two postoperative deaths are excluded, the five-year survival rate becomes 41.2 per cent. This is similar to the findings of Allen, who reported a 40 per cent five-year survival rate

TABLE VI

GASTRIC RESECTION FOR GASTRIC ULCER
GASTRIC ULCERS—MALIGNANT
END RESULTS IN 18 PATIENTS WHO SURVIVED OPERATION

Survival Period	Living	Dead
Less than 1 year		2
Over 1 year	1	2
Over 2 years	1	1
Over 3 years		1
Over 4 years	3	
Over 5 years	2	
Over 6 years	1	
Over 7 years	3	1

7 Five year survivals =
36.8 per cent including operative deaths
41.2 per cent excluding operative deaths

TABLE VII

GASTRIC RESECTION FOR GASTRIC ULCER—1926-1945 INCLUSIVE

1. Cases included in present study of end results	138
2. Cases which have been followed for less than two years	17
3. Cases of gastric ulcer with superimposed malignancy—microscopical evidence	19 (10.1%)
4. Operative deaths	15 (7.9%)
5. Total number of resections performed	188

(One case is included in both groups 3 and 4)

including operative deaths in a similar group of malignant lesions. When it is remembered that the number of five-year survivals in the average reports of cancer of the stomach is in the neighborhood of 20 per cent of the cases resected, it becomes apparent that an aggressive attitude toward gastric ulcer should assist in improving the present poor results in the treatment of gastric carcinoma.

METHOD OF EVALUATION OF END RESULTS

It is a well-known fact that a final judgment of the results of treatment is possible only after many years when one is studying a lesion such as gastric or duodenal ulcer. For that reason we have arbitrarily excluded from final consideration all patients who have not been observed for at least two years postoperatively. This automatically eliminates 12 patients who were operated upon during 1945 as well as five others operated upon earlier but who died of intercurrent disease in less than two years. There have been no unsatisfactory results in these groups.

There remain 138 cases (Table VII) suitable for evaluation of end results and these have been followed for periods ranging from two to 20 years. Data are available on all of these patients. The information has been obtained principally through return visits for check-up examinations, but also by letters, questionnaires and telephone conversations with both patients and their physicians and finally, in case of death, from the Michigan State Department of Health. The follow-up study has been a continuous one, having been inaugurated many years ago. For the present purpose, the various reports for each patient have been assembled and a rating given based upon the combined

evidence. Emphasis has been placed upon the most recent reports inasmuch as occasionally a shift in position up or down the scale becomes necessary, even after a number of years. As a rule changes have been for the better,

TABLE VIII

DURATION OF FOLLOW-UP STUDY—155 CASES

Number of Years After Operation	Living	Dead
Less than 2 years	12	5
2–5	43	14
5–10	34	10
10–15	10	10
15–20	9	7
Over 20	..	1
Total	108	47

TABLE IX

GASTRIC RESECTION FOR GASTRIC ULCER
CAUSE OF DEATH IN 47 PATIENTS WHO HAVE DIED SINCE DISCHARGE

Cause of Death		No. of Cases
1. Cardio vascular disease		18
Cerebral hemorrhage	7	
Cardiac disorders (including coronary thrombosis)	9	
Rupture aneurysm aorta	1	
General arteriosclerosis	1	
2. Pulmonary disease		9
Pneumonia	5	
Pulmonary tuberculosis	3	
Lung abscess	1	
3. Trauma		8
4. Jejunal ulcer		3
5. Renal disease		2
Pyelonephritis	1	
Chronic nephritis	1	
6. Miscellaneous		7
Carcinoma of remaining gastric pouch	2	
Carcinoma of colon	1	
Meningitis	1	
Alcoholism	1	
Suicide	1	
Unknown	1	

TABLE X

SUMMARY OF END RESULTS OF GASTRIC RESECTION FOR BENIGN GASTRIC ULCER

Type of Result	No. of Cases	Per Cent
1. Excellent	86	62
(a) Completely symptom free	65	
(b) Very slight symptoms	21	
2. Good	41	30
3. Poor	7	5
4. Jejunal ulcer (verified)	4	3
Total	138	100

Satisfactory results in 127 cases = 92 per cent

although occasionally the reverse is true. For example, some patients who for a time were classified as only improved, because of their inability to regain strength or maintain proper weight have finally overcome this trouble and have been shifted to the excellent group. Again certain other patients whose

residual symptoms were principally related to the small size of the remaining stomach have in time compensated for this difficulty and now remain among the excellent result cases. Patients who have developed jejunal ulcers and most of those who have obtained poor results have had a poor record from the beginning. For convenience a classification consisting of four categories has been employed. These are: (1) Excellent; (2) Good; (3) Poor; and (4) Jejunal ulcer (verified).

In Table VIII the duration of the follow-up study is analyzed and here it will be seen that 108 patients are still living and 47 are dead. These figures include for completeness the 17 cases under two years which are not included in the final calculations. Table IX gives the causes of death in the 47 patients who have died. It will be observed that death in three cases was due to jejunal ulcer and, in fact, it occurred following secondary or tertiary operations for this condition.

REMOTE RESULTS

In general the end results have been extremely satisfactory and in only 11 cases or 8 per cent have definitely unsatisfactory results occurred (Table X). One hundred twenty-seven patients or 92 per cent have entirely satisfactory results, whereas 86 of these can be classified as excellent.

1. *Excellent results.* This is by far the largest group and is composed of 86 patients or 62 per cent. Sixty-five patients or 75 per cent of this group and 47 per cent of the entire series are completely symptom free and restored to a state of normal health. They eat normally without restrictions, are entirely rehabilitated as far as their economic or social status is concerned and suffer

TABLE XI

GASTRIC RESECTION FOR GASTRIC ULCER
SUMMARY OF CASES WITH EXCELLENT RESULTS—86

Completely symptom free		65
Minimal symptoms		21
Slight weakness	6	
Slight intolerance to certain foods	19	
Fats	9	
Condiments, etc.	6	
Coarse foods	5	
Acid foods	3	
Sweets	2	
Coffee	1	
Ice cream	1	
Milk	1	
Soft drinks	1	
Alcoholic liquors	1	
Nuts	1	

no postresection symptoms. Even on careful questioning no complaints can be elicited. The remaining 21 patients in this group of 86 are also considered as having excellent results. They are well, free from their ulcer symptoms, but on careful questioning report trivial, insignificant or inconsequential symptoms. The latter are not disturbing and consist either of slight weakness or slight intolerance to certain foods (Table XI). A group of normal individuals

would probably show a similar incidence of such symptoms. Fatty foods, for example, pork, fried foods, gravies and rich pastries are troublesome for the largest number of patients. Second in importance are the highly seasoned foods, *e.g.*, pickles, condiments, spices, etc., and third, coarse foods with considerable residue, such as radishes, cucumbers, celery, cabbage, etc. None of these patients requires a special diet and all can remain symptom free by merely avoiding the objectionable items. As far as these 86 patients are concerned the results may be cited as among the best seen following any type of surgical operation of similar magnitude.

TABLE XII

GASTRIC RESECTION FOR GASTRIC ULCER
Analysis of Good Results 41 Patients

Symptoms	No. of Cases
Weakness	11
Symptom free, but adhere to diet	3
Referable to small size of stomach	11
Referable to hypoglycemic or "dumping" syndrome	9
Specific food intolerance	18

Fats	13	Sweets	4
Coarse foods	6	Milk	3
Condiments, etc.	6	Acid foods	1

* * * *

Symptoms partially or wholly due to associated disease—20 patients

Arthritis	4	Hemochromatosis	1
Cholelithiasis	3	Macrocytic anemia	1
Heart disease	3	C.N.S. lues	1
Carcinoma of gastric pouch	2	Ch. nephritis	1
Carcinoma of colon	1	Pul. tuberculosis	1
Diabetes	1	Hypertension	1

2. *Good results.* Forty-one patients or 30 per cent of the group have been placed in this category. These patients are much improved since operation and have remained so. They cannot be said to be completely symptom free, but their symptoms are quite easily kept under control. For the most part the residual symptoms are related to the reduced capacity of the stomach and the altered mechanics of gastric emptying rather than simulating the original symptoms. In Table XII an attempt has been made to analyze and classify these residual symptoms. This group of patients is the one most difficult accurately to appraise. The cases seem to fall conveniently into the following groups although some overlapping necessarily occurs: (a) patients who are not as strong as formerly. Inability to regain former strength is not infrequent and often is associated with failure to regain or maintain weight. These persons require more sleep along with regular hours of work and their physical endurance is somewhat below par. They often are more susceptible to upper respiratory tract infections; (b) patients who are entirely symptom free, but, because in the past they have become so accustomed to following a rigid ulcer diet, they now refuse to discontinue it for fear of further trouble. Some of these patients probably belong in the excellent group; (c) those whose

symptoms are due to the small capacity of the remaining stomach. These individuals are apt to experience discomfort after a heavy meal, from overeating or from eating too rapidly. Many of these symptoms improve gradually as the gastric pouch dilates; some patients never overcome them; (d) those who have symptoms of sweating, a sensation of warmth, cardiac palpitation and faintness and weakness after meals. These have been ascribed by Custer, Butt and Waugh[13] and others to the dumping syndrome and explained by the rapid entrance of food into the jejunum. It is common experience among roentgenologists to observe rapid emptying of the gastric remnant after subtotal resection whereas only a few patients experience this train of symptoms. Many patients with such symptoms in our experience exhibit definite evidence of spontaneous hyperinsulinism and are relieved by the use of a high protein, low carbohydrate diet; (e) patients who have specific food intolerances similar to those mentioned above but more severe and often necessitating a modified diet for control.

It is important to note that one-half of the patients in this group with residual symptoms have co-existing diseases quite capable of accounting for all or many of their complaints. Thus, three of the living patients have definite roentgen evidence of cholelithiasis and one whose complaint is severe weakness has recently been shown to have developed macrocytic anemia. One patient has bronzed diabetes. Two patients have died of carcinoma developing in the gastric remnant. Presumably their gastric symptoms which returned after several years of complete freedom were due to the new disease, as the microscopic examination of the original ulcers showed them to be benign. Another patient subsequently developed carcinoma of the colon from which he died and which probably explained his symptoms. Other lesions more difficult of evaluation and for the most part occurring singly are listed in Table XII. It is not surprising to find such associated disorders frequently in a group of patients such as these who are at or beyond middle age.

These results compare favorably with those of St. John Harvey Guis and Goodman[14] who reported 90 per cent of the survivors of operation as having satisfactory results when grouped according to cases and 92 per cent satisfactory years according to their methods of tabulation. Walters and Clagett[15] state that the results of the surgical treatment of chronic gastric ulcer are among the best in the field of surgery.

3. *Poor results.* Seven patients or 5 per cent of the group have unsatisfactory or poor results not due to stomal ulcer. These are summarized in Table XIII. Four patients are living and three have died at 7 years 9 months, 11 years and 2 months and 18 years and 2 months respectively. Three women who had a conventional type of resection have continued to have the same symptoms following operation. Repeated attempts by various methods of examination have failed to reveal an anastomotic ulcer and the long time which has passed with no essential change in the clinical picture militates against this diagnosis. One of these patients was re-explored 12 years after the original operation for a suspected marginal ulcer, but only a small gastric polyp was

found and removed. Her symptoms remained unchanged. An adequate explanation of the poor results so similar in these three cases is difficult or impossible and perhaps relates to some underlying functional disorder in addition to the organic disease. One man who had a Finsterer type of resection remained in poor health until the time of his death by suicide seven years and nine months later. He was a frequent visitor at the hospital on the Neurology

TABLE XIII

GASTRIC RESECTION FOR GASTRIC ULCER
Analysis of Poor Results—7 Cases

No. of Cases	Comment	
3 Classical operation	Persistence of original symptoms	1 died 18 yrs. 2 mos. 1 living 5 yrs. 8 mos. 1 living 3 yrs. 10 mos.
1 Finsterer operation	Organic brain disease—alcoholism	Died (suicide) 7 yrs. 9 mos.
1 Palliative gastrectomy	Reactivation of ulcer (hemorrhage)	Living 12 yrs. 8 mos.
1 Total gastrectomy	Severe post-resection symptoms macrocytic anemia	Living 5 yrs. 4 mos.
1 Classical operation	Incisional hernia (intermittent obstruction)	Died 11 yrs. 2 mos.

service. An anastomotic ulcer was never demonstrated and due to his demented state, institutional care was required. The one patient upon whom a palliative gastrectomy was performed in our opinion has not had a satisfactory result.

He developed symptoms of reactivation of his unremoved ulcer two years postoperatively. Strict dietary and medical management have sufficed to hold the disease in check. Stomal ulcer in this case has been excluded to the best of our knowledge. One of the three patients who underwent total gastrectomy has a poor result in the form of severe post resection symptoms. He is a severe psychoneurotic, has pronounced hyperinsulinism and has recently developed macrocytic anemia. The final case in this group is listed here in spite of an apparent cure of his ulcer due to the fact that a large incisional hernia developed after operation. Until the time of his death 11 years and two months later, he had symptoms of intermittent intestinal obstruction. He repeatedly refused to have the hernia repaired and while the clinical results in this case must necessarily be recorded as poor, it should not stand as an indictment against the operation as far as the ulcer results are concerned.

4. *Jejunal ulcer.* Jejunal ulcer, while of rare occurrence, following gastrointestinal anastomoses for gastric ulcer is a most serious and distressing complication when it occurs. Church and Hinton[16, 17] reported three marginal ulcers in nine cases of gastric ulcer treated by gastroenterostomy and a questionable recurrent ulcer in one case treated by resection. Heuer reported three cases in which a stomal ulcer following resection was suspected but not proven. There were four verified jejunal ulcers in the present series. The pertinent clinical data of these cases are epitomized in Table XIV.

The first case is an example of a patient who required multiple operations for repeatedly recurring marginal or jejunal ulcers. This man was operated upon three times for recurrences. The original lesion was a high lesser curvature ulcer and a fairly radical Polya resection was performed. The

antrum, however, was not removed. Apparently it was left for the sake of simplifying the operative procedure. Accordingly this patient should be regarded as one who did not have an adequate primary resection. Unfortunately at the subsequent operations the antrum and pylorus were not excised. The second case is very similar and in view of the evidence now available, it is quite certain that the Finsterer procedure should never be used when dealing with gastric ulcer. In addition to the fact that one-half of the end results of this operation were unsatisfactory it is noteworthy that none of the remaining cases were in the excellent group. The third case is one in which a type of Finsterer operation was probably performed although not intentionally. The

TABLE XIV

JEJUNAL ULCER—4 CASES

Case	Recurrence	Subsequent Course
1. M 52—Posterior polya (Finsterer) 8-3-27	8 mos.	(1) Reresection 9-26-28 (2) Closure of acute perforation (elsewhere) Dec. 1937 (3) Exclusion of jejunal ulcer 8-12-38 (4) Died (cerebral hemorrhage) 1-5-39
2. M 55—Posterior Hoffmeister (Finsterer) 7-18-28	18 mos.	(1) Exploratory and jejunostomy 11-6-30 (4) Died 11-28-30. No autopsy
3. M 61—Posterior Hoffmeister (Finsterer) 4-1-43	Immediately Gastrojejuno-colic fistula	(1) Resection duodenal stump 5-19-44 (2) Colostomy and jejunostomy 4-25-45 (3) Died 6-23-45. Autopsy—perforation-peritonitis
4. F 69—Posterior Hoffmeister 1-27-44	9 mos.	(1) Reresection 5-17-46 (2) Died 5-18-46. Hemorrhage. No autopsy

lesion was on the lesser curvature and associated with a good deal of inflammatory reaction. The lower transection is stated to have been "close to" the pylorus. Symptoms of a marginal ulcer occurred promptly and one year later it was thought advisable to resect the upper portion of the duodenal stump. McKittrick[18] and Marshall[19] have reported nine cases in which jejunal ulcers have healed following such an indirect attack. Interestingly enough histologic examination of this specimen revealed the presence of gastric mucosa, but unfortunately the ulcer was uninfluenced by the procedure and progressed to the stage of a gastrojejunocolic fistula. Later, perforation occurred with a resultant general peritonitis in spite of the fact that the fistula had been excluded by a proximal colostomy and a catheter jejunostomy for feeding purposes. The remaining case in this group is that of a woman of 69 who had a prepyloric ulcer. A conventional resection which was adequate according to all of the usual criteria was performed. One year later a jejunal ulcer was easily demonstrated roentgenographically. At this examination it was estimated that two-thirds of the stomach had been removed. Gastric acidity remained at about normal levels prior to reresection. It is conceivable in this case that antral tissue was left behind in the upper segment by removal of too little of the lesser curvature, and that a higher resection might have given a better result.

WEIGHT CHANGES

The post resection changes in weight are given in Table XV. An attempt was made to compare the stabilized postoperative weights as attained several years after operation with those of the patients before the procedure. The preoperative weight selected was the average or possibly the best past weight. The weight immediately before operation is a poor criterion as most of these patients had lost from 15 to 25 pounds during the several months prior to surgery and a comparison with this weight would show either little or no change or more probably a gain. It will be noted that after resection the average patient is nearly 12 pounds below his former weight. Rarely is the loss excessive or sufficient to cause concern. It may, however, be associated with loss of strength and in some cases this may become a difficult problem. An

TABLE XV

POST RESECTION CHANGES IN WEIGHT—112 CASES

Change	No. of Cases	Range (Pounds)	Average (Pounds)
Loss.....	84(75%)	5–45	17
Gain.....	15(13%)	3–25	10
No change.....	13(12%)	....	..

Overall average, 11.7 pounds loss

interesting study of this matter has been made by Wollager, Comfort, Weir and Osterberg[20] who found that following the Polya type of resection nearly all persons lost more fat in the stool when taking a high fat diet than did those who had not had a gastric resection. This was also true in some patients who were on a diet of ordinary fat content. Moreover some patients after the Polya operation lost more nitrogen and total solids in the stool than did normal individuals. The authors conclude that the amounts of fat and nitrogen lost in the feces were not large, but unless a diet of sufficient caloric content to compensate for this loss is taken a decrease in body weight might be expected.

SUMMARY

The end results of gastric resection for gastric ulcer as viewed over a 20-year period support the earlier impression that this is the best means now at our disposal for the treatment of those ulcer cases which require surgery. The operation has limitations and for patients who are exceedingly obese are poor risks or who have high or inaccessible lesions, a less ideal but safer procedure should be selected. With the advent of vagal interruption a new and potent method is available for this group of cases. It is also conceivable that, as suggested by Lahey,[21] subdiaphragmatic vagotomy may be worth while at the time of subtotal gastrectomy in an attempt to prevent jejunal ulcer in that small group of patients who may be expected to develop this complication even after an adequate resection. The conventional subtotal resection whereby a large portion of the lesser curvature as well as the antrum and pylorus were removed, has given the best results in this series. Little difference has been noted in the late results between those cases in which a Polya or a Hoffmeister

reconstruction was performed, and likewise the clinical results of cases of antecolic and retrocolic anastomoses were essentially the same.

The Finsterer exclusion operation would seem to have no place in the treatment of gastric ulcer and in view of a better understanding of gastric physiology it should be abandoned. Palliative gastrectomy, as observed in one case, did not yield a satisfactory result and it would seem that today there are other and better methods of dealing with high gastric ulcers. The record of the three total gastrectomies is not good. Although there was one excellent result, there was one operative death and one poor result. The procedure seems much too radical for the treatment of a benign ulcer but for the type of case in which it was here employed any substitute operation must be one which includes removal of the ulcer. In general an operation with 92 per cent of satisfactory end results compares favorably with the results of almost any major surgical operation today. The operative mortality herein reported can most certainly be reduced in the future and by heeding some of the lessons learned from this study it is hoped that the unsatisfactory clinical results can be further reduced in number.

The fact that microscopical study revealed malignancy in 10 per cent of the lesions which was not recognized as such at the time of laparotomy would indicate that any indirect operation for gastric ulcer should be accepted with caution. We believe that there is a definite place for medical treatment in the management of certain gastric ulcers but that its dangers and limitations should be realized by internists as well as surgeons. The side-effects resulting from large gastric resections which occasionally occur in the form of post resection symptoms and nutritional disturbances are perhaps the most objectionable feature of the operation. Fortunately most patients experience but little inconvenience on this score, but as newer and better methods of treatment become available, it is to be hoped that all postoperative residual symptoms can be eliminated.

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DISCUSSION.—DR. ROSCOE R. GRAHAM, Toronto: Dr. Ransom was good enough to make available the material in his paper prior to his address. He has rightly stressed that the proper therapy in gastric ulcer is still predicated on our ability or lack of ability to differentiate a benign from a malignant ulcer. It is noteworthy that in his series there was a 10 per cent error in considering as benign an ulcer which histologically was proven to be malignant. In a series of our own cases the error was as high as 17 per cent. Some years ago Dr. Harold Wookey re-examined specimens in our museum which had been labelled as benign gastric ulcer. More detailed histologic study showed that 18 per cent were malignant.

Singleton and Summers reported on 309 patients suffering from pre-pyloric lesions; 189 were carcinoma and 120 were benign lesions. It was interesting, however, that in 24 of the malignant cases the crater was the only index of abnormality and in 17, or 85 per cent of these the crater was less than 2.5 centimeters in diameter.

In a follow-up series of gastric carcinoma, there were a few cases in which it was felt that the carcinoma had been grafted upon a previous chronic ulcer. While these could have been controlled by earlier surgical excision of the ulcer, it was heartening to find that the prognosis in such a gastric carcinoma was better than in one which started primarily as a carcinoma.

Previously we have withheld operation on patients suffering from gastric ulcer until our hand was forced. In most instances we had not advised operation until there was involvement of contiguous structures in practically all cases. This gave a definite mortality and a difficult technical problem. With the data which Dr. Ransom has presented, it becomes obvious that one should entertain very seriously the policy of advising early radical operative procedures for a patient with a gastric ulcer. The present regimen of preoperative care for gastric patients enables a radical gastrectomy to be carried out

without a prohibitive mortality. We are therefore justified in advising patients suffering from what we believe to be a benign gastric ulcer to accept operation early in the course of the disease.

We believe that the operation should be a radical gastrectomy. We have never accepted the Finsterer type of operation, in which a portion of the pyloric antrum was left in situ, even though a radical resection of the stomach was done. It is our conviction that the pyloric mucosa should be removed in its entirety in cases of gastric resection for ulcer.

DR. F. B. ST. JOHN, New York: It is the type of report which Dr. Ransom has just made, representing a careful study of 175 cases of gastric ulcer which have been treated by partial or subtotal gastrectomy, which brings out informative material and matters for further consideration. Following the cases carefully, as has been done in this series, is of course the outstanding factor in evaluating the results. One cannot help but be impressed in general by the very satisfactory results obtained in his clinic.

The paper also introduces the interesting group of cases in which carcinoma was either suspected or actually proven either at operation or later in the surgical pathologic laboratory.

Dr. Harold D. Harvey, an associate on the surgical staff of the Presbyterian Hospital in New York, and I are about to finish a review of some 400 cases of subtotal gastrectomy for duodenal and gastric ulcer in the last ten years. The results have been gratifying in that the cases without symptoms of any significance followed on an average of about four years, show that 85 per cent have had no trouble. If the cases that either died or were lost to follow-up are eliminated, it would be approximately 90 per cent. In following these cases, we record any one of them as unsatisfactory if at any time during the follow-up period symptoms of significance have appeared. The work will be published in the near future. We realize fully that subtotal gastrectomy is by no means the satisfactory answer to these chronic inflammatory lesions of the stomach and duodenum as an ultimate form of therapy.

In our follow-up clinic we do not speak of end results in the course of a follow-up period, as we prefer to follow our cases in continuity and no ulcer case is closed, so to speak, so that we are establishing records of greater longevity which eventually will be of greater value. Any student of this disease will appreciate the importance, I think, of this method of following cases.

A word about operative mortality during the ten-year period represented by this study. In our series it was 4.6 per cent, but of the 18 postoperative deaths 16 occurred in patients over the age of 45, the death rate for patients under 45 being between 1 and 2 per cent, whereas in the older age group it was about 7 per cent, and in this latter age group cancer had been suspected in almost half the cases. Hence the feeling that resection was indicated in any event.

Another interesting point in Dr. Ransom's results is the fact that if one studies a large series of cases, such as in the past 20 years, it must needs include a number of limited partial gastrectomies, in the first decade especially, and it is well known that the results in this type of procedure are not as satisfactory.

DR. FRANK H. LAHEY, Boston: I do not wish to add anything concerning the matters particularly discussed in this paper, but to bring before this busy surgical audience one point, and that is, how are we going to make the decision in patients with gastric ulcers; in which case we should apply and continue medical treatment, in which not to, and on what basis? I am well qualified to speak on this subject, since I have promoted over the years a set of criteria for applying medical measures to patients with gastric ulcers which I would like now to relinquish publicly.

I have said over the years that if a patient with a gastric ulcer showed freedom from symptoms, the absence of occult blood in the stools, and if the lesion disappeared by roentgenologic examination, he could be treated medically. I would like to change this

position and state that I now believe that every patient with gastric ulcer should have a gastric resection, and for the following reasons: Our present mortality in the resection of 110 consecutive gastric ulcers is zero, compared with a mortality of 2.6 per cent in approximately 400 subtotal gastrectomies forduodenal ulcer and 2.2 per cent in approximately 100 consecutive subtotal gastrectories for jejunal ulcer. I believe that all gastric ulcers should be resected because we have found it impossible in doubtful cases to be sure that patients come back often enough to be checked adequately against malignancy and too many of them, when they have returned because of distressing symptoms, have been found to have an inoperable malignancy. I believe that the situation with gastric malignancy is so depressing that, particularly when subtotal gastrectomy for gastric ulcer can be done with such a low mortality, enough early carcinomas will be discovered to make the operation worth while. I believe in any lesion in which the pathologist himself, unless he makes serial sections, is often unable to determine whether or not malignancy is present, that there are no methods by which surgeon, gastroenterologist or medical man can be sure that he is not carrying on medical treatment in one out of ten patients who may well have cancer of the stomach.

There is no question but that there will be some ulcers resected which could have been treated medically, but the fatality percentage in this group from subtotal gastrectomy will, in my opinion, be infinitely lower than would be the case if some of these patients were treated medically and the malignancy overlooked until any prospect of cure by surgery was lost.

Dr. Henry K. Ransom, Ann Arbor, Mich. (closing): I wish to thank Drs. Graham, St. John and Lahey for their comments. Dr. St. John mentioned some of the difficulties encountered in the follow-up work. This has been true especially in our group listed as "good" results. These patients have been relieved of their original complaints but have some residual symptoms of different sorts. On careful examination many are found to have other diseases such as gallstones, syphilis, heart disease, etc., which could account for some or all of their symptoms.

An evaluation of the results of surgical treatment must take into account the operative mortality. Our mortality for this series was 7.9 per cent. I am glad that Dr. Lahey emphasized the point that at the present time this has fallen to a low level as evidenced by his excellent record of no deaths in a large group of cases.

One of the difficulties encountered after operation in certain patients is the syndrome sometimes referred to as the dumping stomach. These individuals experience a feeling of weakness, sweating and cardiac palpitation after meals. In certain of these cases we have found the condition of alimentary functional hyperinsulinism. The fasting blood sugar is normal but after the ingestion of glucose, the level at the end of the first hour rises far above the normal reading. This is presumably due to the rapid filling of the jejunum with chyme due to loss of the pyloric mechanism. In turn, an unusually rapid absorption of dextrose takes place. The high blood sugar then stimulates the normal islet cells of the pancreas to an excessive release of insulin which brings the blood sugar down to hypoglycemic levels at the end of the second or third hour. Thus, instead of being about 65 mg. per cent at this time it is often as low as 35 or 40 mg. per cent. This mechanism seems to offer a plausible explanation in some patients for the train of symptoms often referred to as the dumping syndrome. In our experience the best treatment consists in the use of a high-protein, low-carbohydrate diet.

THE EFFECT OF VAGOTOMY ON HUMAN GASTRIC FUNCTION*

A Preliminary Report

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THE FIRST ATTEMPTS to treat peptic ulcer surgically by gastric denervation, produced results which were difficult to evaluate. These indifferent reports, the different kinds and degree of denervation attained, the lack of understanding of the rationale, and the failure to pursue the problem further, apparently caused the procedure of vagotomy for peptic ulcer to remain obscure.[1, 2, 3] In recent years, however, the procedure has been revived in a different light, based upon a better understanding of the physiology of the stomach and of the ultimate cause and mechanism by which peptic ulcer is produced.[4, 5, 6, 7, 8, 9] It is the opinion of many that the ultimate cause of the lesions is secondary to (1) alterations of psychogenic or neurogenic origin, (2) alterations of the functions of cells of internal or external secretion, (3) local alterations of the mucosal anatomy or physiology of the affected mucosa, or (4) a reduction of the constituents of gastric contents produced by other organs, viz., hepatic, duodenal, salivary, or pancreatic secretions. Likewise, it is generally believed that the mechanism of ulcer production is the proteolytic activity of the gastric contents versus the mucosal resistance to devitalization and ulceration.

With the revival of this neglected procedure, comes the repeatedly demonstrated observation that complete section of the vagus nerves to the stomach does permit rapid healing and prolongation of remission of benign peptic ulcer.[10, 11, 12, 13, 14] It is strongly felt that this favorable therapeutic response comes from an attack upon the mechanism of ulcer production, and more specifically, upon the proteolytic or peptic activity of the gastric contents. That continuous and prolonged reduction of peptic activity is necessary to obtain a therapeutic response is evident from the fact that if the ulcer is to heal, it must be given sufficient time. This healing time is achieved not by a temporary adequate reduction but by a sufficiently prolonged reduction of the peptic power of the gastric contents. Since peptic power is dependent upon products of gastric function, i.e., acid and pepsin, then the effect of vagotomy upon function could explain the therapeutic response.

The effect of complete parasympathetic denervation of the stomach is a lack of secretory and motor response to vagus stimulation, *i.e.,* the cephalic phase is abolished. The response to humoral secretagogues, however, is not prevented by such denervation. The stimulation of intact vagi to the normal or ulcerated stomach produces a copious secretion of gastric juice high in proteolytic activity as well as an increase in gastric motility.[15, 16] The prevention

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of this stimulus to gastric function, therefore, would abolish the cephalic phase and the part it plays in the mechanism of ulceration. On the other hand, since gastric contents can be strongly proteolytic in the absence of vagus stimulation, it remains to be shown that a complete vagotomy will always produce a sufficient reduction in the peptic activity to permit an ulcer to heal or prevent its recurrence.[17, 18]

PURPOSE

The purpose of this report is (1) to point out the fallacies of continuous gastric suction as a method for determining the volume of gastric secretion, (2) to describe briefly a new method for measuring the function of the human stomach, and (3) to present graphical data showing the usual response to some stimuli of the nervous and humoral phases of gastric function before and after vagotomy. The functions studied are (1) rate of secretion, (2) rate of emptying, (3) pH of secreted gastric contents, and (4) digestive power of secreted contents.

MATERIAL

The material studied consisted of 30 patients. Twenty-one were operated upon above the diaphragm, and nine below. Postoperative tests and clinical responses indicated that a complete vagotomy was achieved in each instance.

METHOD

A common method for measuring the volume of gastric secretion depends upon the complete recovery, by continuous suction on a stomach tube, of the total volume of juice secreted. This method is unsatisfactory because (1) a large portion of the secretion is emptied through the pylorus and therefore is not recoverable, (2) if any duodenal regurgitation occurs at any time during the period of continuous suction, it will be recovered in part and will increase the volume aspirated, (3) during a period of prolonged suction, or while the subject is asleep, saliva will also enter the stomach and be recovered, and finally (4) it is difficult to empty completely a stomach if the subject remains in one position during the period of aspiration.

The method employed in these studies for the quantitative determination of human gastric function has been reported elsewhere.[19] It consists of injecting into the empty stomach an isotonic solution containing a known amount and concentration of an indicator (phenol red), and after a 15-minute period aspirating the entire gastric residual contents. From the values of quantity and concentration of indicator injected and aspirated, can be calculated the average rates of gastric secretion and emptying during the test period. Evidence for the validity of the method has been obtained. Figure 1 is a simple graphical representation of the principles upon which the method is based. It is obvious that if the quantity of indicator in the stomach contents remains unchanged, no emptying has occurred. If the concentration decreases, then there is dilution of indicator by gastric secretion. From the middle graph, if the concentration of indicator remains unchanged, no secretion has occurred. But if the quantity decreases, then there is loss of indicator by emptying of

gastric contents through the pylorus. If both the concentration and quantity are decreased, then both secretion and emptying have occurred. The concentration of indicator injected and aspirated is determined by an electric colorimeter after precipitating proteins and bile, if any is present.[20] The volumes injected and aspirated are measured, and the quantity of indicator content is then calculated. C_0 = indicator concentration of injected solution, and W_0 = quantity (weight) of indicator injected. C_T and W_T are concentration and quantity at the end of a test period. Calculations of pH and peptic activity of secreted contents can readily be made.

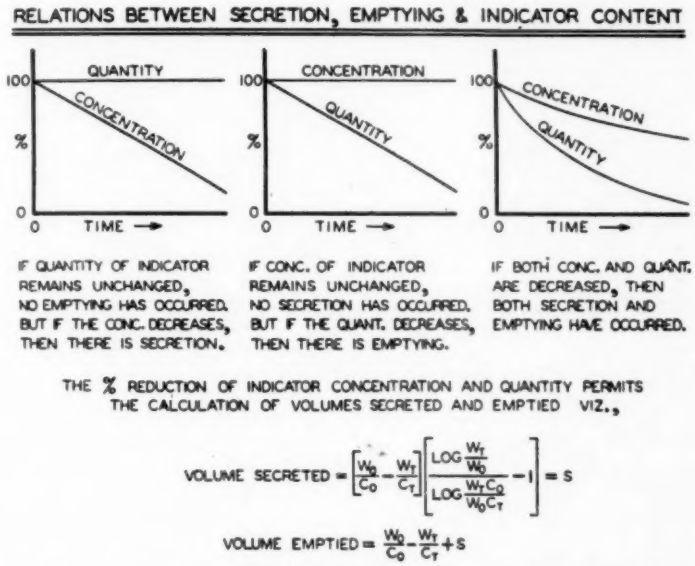
RELATIONS BETWEEN SECRETION, EMPTYING & INDICATOR CONTENT
100
%
0
QUANTITY
CONCENTRATION
TIME
IF QUANTITY OF INDICATOR REMAINS UNCHANGED, NO EMPTYING HAS OCCURRED. BUT IF THE CONC. DECREASES, THEN THERE IS SECRETION.
CONCENTRATION
QUANTITY
IF CONC. OF INDICATOR REMAINS UNCHANGED, NO SECRETION HAS OCCURRED. BUT IF THE QUANT. DECREASES, THEN THERE IS EMPTYING.
IF BOTH CONC. AND QUANT. ARE DECREASED, THEN BOTH SECRETION AND EMPTYING HAVE OCCURRED.
THE % REDUCTION OF INDICATOR CONCENTRATION AND QUANTITY PERMITS THE CALCULATION OF VOLUMES SECRETED AND EMPTIED VIZ.,
VOLUME SECRETED = $\left[\frac{W_0}{C_0}-\frac{W_T}{C_T}\right]\left[\frac{\text{LOG}\frac{W_T}{W_0}}{\text{LOG}\frac{W_TC_0}{W_0C_T}}-1\right]=S$
VOLUME EMPTIED = $\frac{W_0}{C_0}-\frac{W_T}{C_T}+S$

FIG. 1.—Principles of Method for the quantitative determination of volumes of gastric secretion and emptying.

RESULTS

The results of this study are represented by (1) data obtained from the same patient before and after vagotomy in response to nervous and humoral stimuli of gastric function, and (2) the average secretory response to insulin hypoglycemia (a potent stimulus to vagus function) in six subjects without vagotomy and in seven with vagotomy. Figure 2 shows the effect of the subcutaneous injection of 0.275 mg. of histamine acid phosphate upon the secretory and emptying rates. Both secretory rates responded with an increase following the injection of histamine before and after vagotomy. This response is to be expected, because histamine is a humoral secretagogue and its action upon gastric function is independent of intact vagi. Before vagotomy, the increase of emptying rate in response to histamine may have been a consequence of a greater volume of gastric contents produced by the increased secretory rate. Figure 3 shows the effect upon the pH and peptic power of the secreted contents in response to the same drug. There was a marked

increase in the concentration of pepsin and hydrochloric acid (decrease of pH) before and after vagotomy. This response shows again that histamine acts independently of the vagus nerves. Notice the non-parallel relationship between curves of secretory rate and pH.

The response of gastric function to sham feeding before and after vagotomy is shown in Figure 4. The same subject chewed an orange during the period indicated without swallowing any of it. Preoperatively, there was an increase

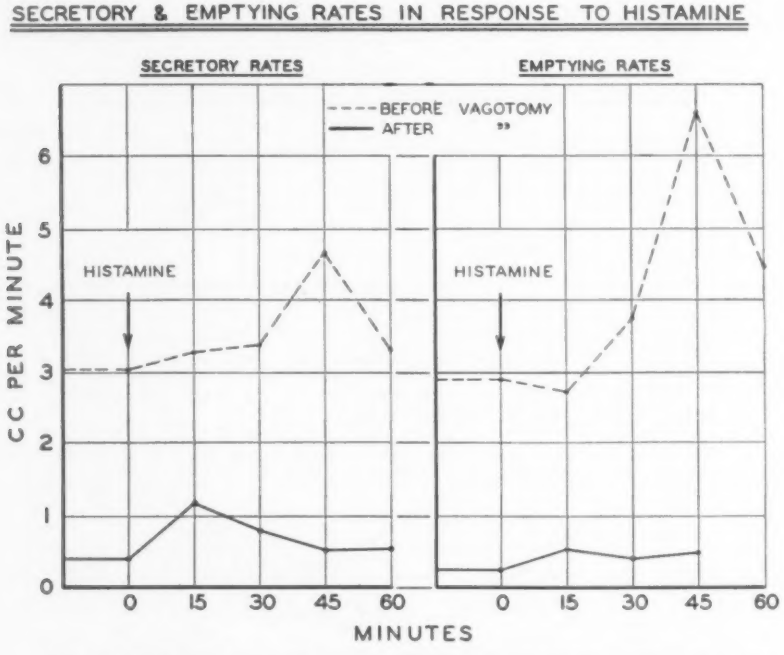

FIG. 2.—Patient J. S. Preoperative test done while patient had an active duodenal ulcer. Postoperative test 64 days after complete vagotomy with no evidence of ulceration. Note response to histamine and the marked reduction of pre-histamine (basal) rates after vagotomy.

in the secretory and emptying rates. Postoperatively there was no response following the sham feeding. These data demonstrate the absence of the cephalic phase of gastric function in a subject with vagotomy. Figure 5 shows the effect upon pH and peptic power of the secreted contents in response to the sham meal. Preoperatively there was a marked increase in the concentration of pepsin and hydrochloric acid after the feeding. Postoperatively, the pH remained unchanged, while the peptic power actually decreased. This again demonstrates the absence of the cephalic phase of gastric function in a subject with vagotomy.

A comparison of the control values (Fig. 2, 3, 4, 5) reveals that all the functions studied were diminished postoperatively. There was a smaller percentage reduction in peptic power than in any of the other three functions. Emptying rates and acidity were most reduced. During the preoperative his-

tamine study, the subject had an active duodenal ulcer, and his control secretory rate was 3 cc. per minute. At the time of the preoperative sham meal study, the ulcer was inactive and the control secretory rate was 1.2 cc. per minute, showing that gastric secretion during exacerbation was two and one-half times the rate during remission. After vagotomy, the control secretory rate was only about 0.45 cc. per minute which is but 15 per cent of the control rate at a time when the ulcer was active. This reduction of secretory rate is the goal of vagotomy, for with no cephalic phase of secretion, the entire burden

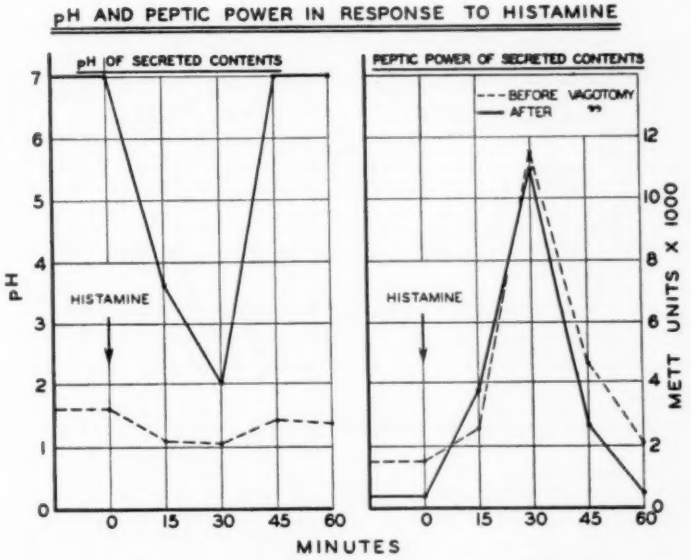

FIG. 3.—Patient J. S. Preoperative test done while patient had an active duodenal ulcer. Postoperative test 64 days after complete vagotomy with no evidence of ulceration. Note response to histamine and the reduction of prehistamine (basal) peptic power and acidity (increase of pH) after vagotomy.

of stimulating the production of sufficient hyperactive digestive juice rests with other secretory stimulants, *e.g.*, humoral secretagogues. In the majority of people these secretagogues apparently are not capable of stimulating the production of enough proteolytic juice of sufficient activity to produce or maintain a peptic ulcer.

Figure 6 shows the secretory response to insulin hypoglycemia before and after vagotomy. Seven tests were done on six subjects without vagotomy, and eight tests were done on seven subjects with vagotomy. This is unselected data and includes all tests done. In each person before vagotomy, the secretory rate was markedly increased after the injection of insulin. Whereas, postoperatively each person responded with a slight but definite decrease in the rate of gastric secretion following the injection of the drug. An explanation for this response is, that the hypoglycemia following the injection of enough

insulin strongly stimulates the vagus nuclei in the medulla. This in turn stimulates the intact vagus nerves to release acetylcholine at the synapse of the nerve endings with effector cells of the stomach. The acetylcholine then acts upon the secretory and motor cells to stimulate their activity, which results in the production of secretion and motility. It follows from this, that if the vagi to the stomach are severed, then the stimulus propagated along the nerve will never reach the stomach, and consequently there will be no increase of gastric function due to stimulation of these nerves by the hypoglycemia. These data indicate that the insulin test, when properly employed, appears as a satisfac-

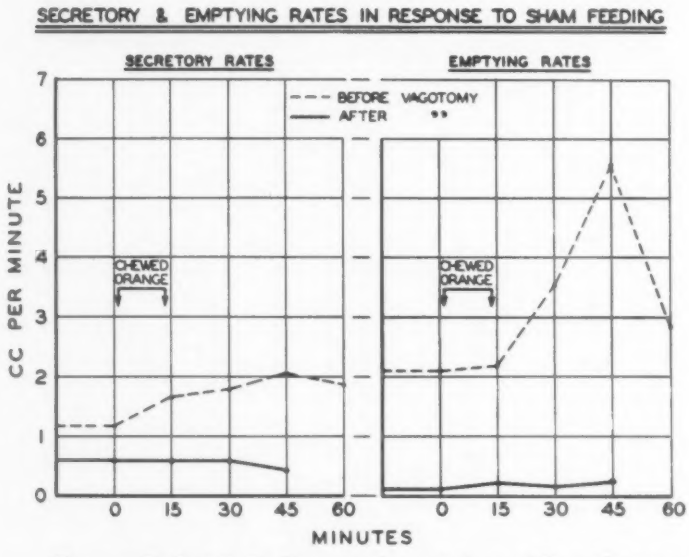

FIG. 4.—Patient J. S. Preoperative test done while patient was in remission from duodenal ulcer. Postoperative test done 64 days after complete vagotomy, with no evidence of ulceration. Note response to the sham-feeding and the reduction of pre-sham-meal (basal) rates after vagotomy.

tory means for determining whether or not the stomach has been sufficiently denervated.

In Figure 6 it can be seen that the average control secretory rate preoperatively was 3.25 and postoperatively 2.09 cc. per minute. This represents a 36 per cent reduction of the average basal gastric secretion in response to vagotomy. However, it has been shown that there is no correlation between the rate of secretion and the concentration of pepsin or hydrochloric acid of the secreted contents. For example, in response to histamine there may be an increase in concentration of hydrochloric acid with no increase in total secretory rate. Therefore, it should be stressed that the volume of secretion produced *per se* gives no indication of the proteolytic power of the gastric contents. With this in mind, and again referring to Figure 6, it should be noted that the basal secretory rate in a person without vagotomy (note preoperative

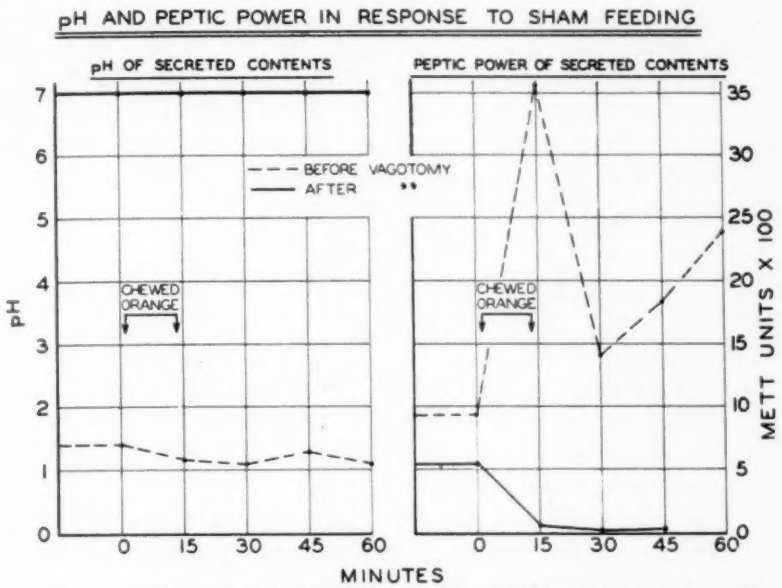

FIG. 5.—Patient J. S. Preoperative test done while patient was in remission from duodenal ulcer. Postoperative test done 64 days after complete vagotomy with no evidence of ulceration. Note response to the sham-feeding and the reduction of the pre-sham-meal (basal) peptic power and acidity (increase of pH) after vagotomy.

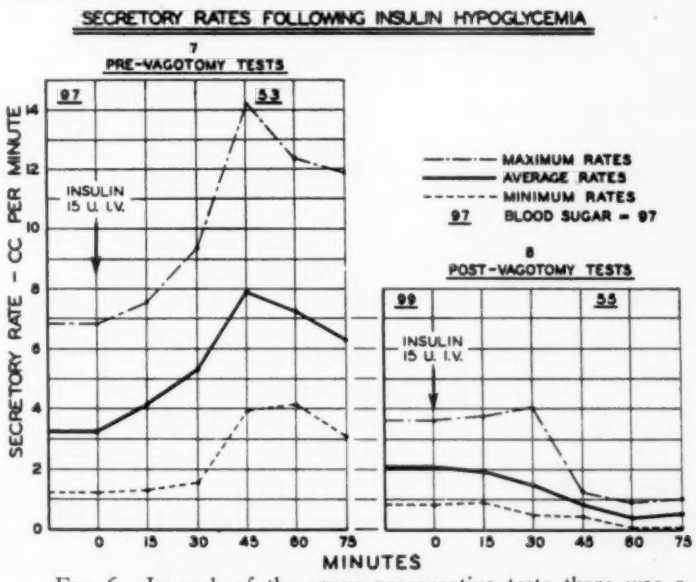

FIG. 6.—In each of the seven preoperative tests there was a marked increase in secretory rate in response to insulin hypoglycemia. In each of the eight postoperative tests there was a reduction of secretory rate after injection of the drug. Note that the average post-vagotomy pre-insulin (basal) rate was 36 per cent less than the average preoperative pre-insulin (basal) rate. Also note that the maximum postoperative pre-insulin (basal) rate is higher than the minimum and average pre-vagotomy pre-insulin (basal) rates. Solid lines represent the average of all tests. Broken lines represent the maximum or minimum tests.

control rate of minimum curve) may be considerably lower than the basal rate in another person with vagotomy (note postoperative control rate of maximum curve). The inference to be drawn from these comparisons is that preoperatively a low rate of basal secretion is no contraindication to vagotomy for peptic ulcer because the peptic power may be high. And likewise, a high rate of basal secretion postoperatively is no criterion for incomplete vagotomy.

SUMMARY AND CONCLUSIONS

1. The mechanism for the production and maintenance of peptic ulcer is the proteolytic activity of the gastric contents versus the mucosal resistance to devitalization and ulceration.

2. The fallacies of continuous gastric suction as a method for determining the volume of gastric secretion have been pointed out.

3. A satisfactory method for the quantitative determination of human gastric function has been reviewed briefly.

4. The gastric secretory response to histamine, a humoral secretagogue, is not prevented by complete vagotomy. Therefore, a vagotomized stomach is still capable of producing active digestive juice.

5. Complete vagotomy reduces gastric secretion and emptying by abolishing the cephalic phase of gastric function. Peptic activity is least reduced.

6. The basal secretory rate of six persons was reduced by an average of 36 per cent in response to vagotomy.

7. In one person, the basal secretory rate fell from 3 cc. per minute during a period of exacerbation of duodenal ulcer, to 1.2 cc. per minute during remission. In this same person, the rate was decreased to 0.45 cc. per minute after vagotomy.

8. The insulin test for complete vagotomy appears to be satisfactory when properly employed.

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VAGUS RESECTION FOR ULCER: AN INTERIM EVALUATION*

II. Clinical Results

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IN THE PREVIOUS PAPER of this series[1] the operative technic, postoperative management, and hospital morbidity and mortality of vagus resection for ulcer have been described. In this paper it is our purpose to present the clinical results in these patients two to 30 months postoperative.

1. CLINICAL DATA

The study of vagus resection at the Massachusetts General Hospital comprises at the present time a group of 84 patients who have had this operation performed. These patients divide themselves into two groups: 41 patients who were cared for on the charity wards of the Massachusetts General Hospital; and 43 patients from the private wards of the hospital who were under the care either of the author or of other members of the surgical staff.†

There are four patients in this group who have had vagus resection for diseases other than peptic ulcer. Six patients have been operated upon too recently to be of value in any consideration of clinical effects. The remaining 74 patients will form the subject of this discussion.

It is, of course, of no significance to use the term "end-result" in a study of ulcer therapy dating back only two and one-half years. Yet an appraisal of the present status of these patients is of the greatest necessity at this time.

The interim results in these patients have been evaluated by a careful clinical follow-up. In addition, within six weeks preceding the preparation of this manuscript, questionnaires were sent to all the patients. The return from these questionnaires included 97 per cent of the group. On the basis of these questionnaires plus the impressions of the physicians who have been following the patients, the clinical results have been ascertained. It should be emphasized that the questionnaire asked questions concerning the patient's ulcer pain, incisional pain, diarrhea, indigestion, and, in addition, gave the patient ample opportunity to express any further thoughts concerning the effects of the procedure on himself.

Follow-up x-rays have not been taken in all cases. This procedure has not been felt necessary unless the patient complained of an ulcer pain or had other disturbing symptoms. In three instances ulcer pain or bleeding occurred post-

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operatively, but by the time the patient was seen or admitted to the hospital all symptoms had receded and a negative x-ray has been of little significance in evaluating the symptomatic episode.

Results from these cases have been classified into three categories:

a. *"Poor" Results.* Patients have been adjudged to have a poor result if they had a frank recurrence of the ulcer, if they had ulcer pain or bleeding symptoms, or both. The classification of poor results may be considered in essence to include cases which have shown some evidence of recurrence, although at the actual time they were surveyed, they may not have had such symptoms.

b. *"Fair" Results.* Fair results have included those patients in whom some postoperative event occurred which detracted very materially from any benefit conferred by the operation. In most instances, these difficulties disappeared within a short time, and the final result was satisfactory to the patient, yet the presence of transient major difficulties would prevent the result from being classified as good. In a few patients having "fair" results the final result at the time of this writing is unsatisfactory to the patient or to the physician, although the ulcer has remained healed.

c. *"Good" Results.* Results are classified as good if the patient himself is satisfied with the result of the operation, if he has maintained himself free from symptoms without diet, and if the gastro-intestinal side-effects of the operation were not significant enough to cause him discomfort during more than a normal period of convalescence such as one might experience after any operation.

This grouping arises in part from the viewpoint of the patient, in the final analysis the only person able to judge the symptomatic result in a disease the course of which over many years may be benign.

This grouping of cases according to clinical result is shown in Figures 1, 2, 3, and 4. Of the 74 cases, 87 per cent have a result satisfactory by the most rigid criteria.

Among the *"poor"* results is included a patient who had a retained gastric antrum removed before he became well.[1, 2] This patient is now well and at work. The case of recurrent ulcer with bronchogenic carcinoma is enigmatic. The patient is asymptomatic, whereas, before vagus resection symptoms were very severe. His duodenal ulcer is present by x-ray only. He has had a total pneumonectomy and the state of his duodenum, when he has recovered from this difficulty, will constitute the significant interim result. The other three patients in the "poor" result group have had ulcer symptoms eight to 30 months postoperatively and must be considered as failures, at least at this point. Their future course will be cause for considerable interest and concern.

The 13 patients with *"fair"* results may be grouped according to the satisfaction of the patient with the present state of affairs. Eight of the 13 are at present satisfied, though their course has been marred by undesirable events as shown in Figure 4. Five of these patients have had so much difficulty

with side-effects that their result must be judged unsatisfactory by any standards. It is of interest that some patients regarded as having unsatisfactory results in a previous report[2] have now cleared up their troubles and are well, at work, and satisfied. This intermediate classification is, therefore, a shifting one; it represents the status of patients at this phase of their convalescence and may increase or decrease in importance as time goes on.

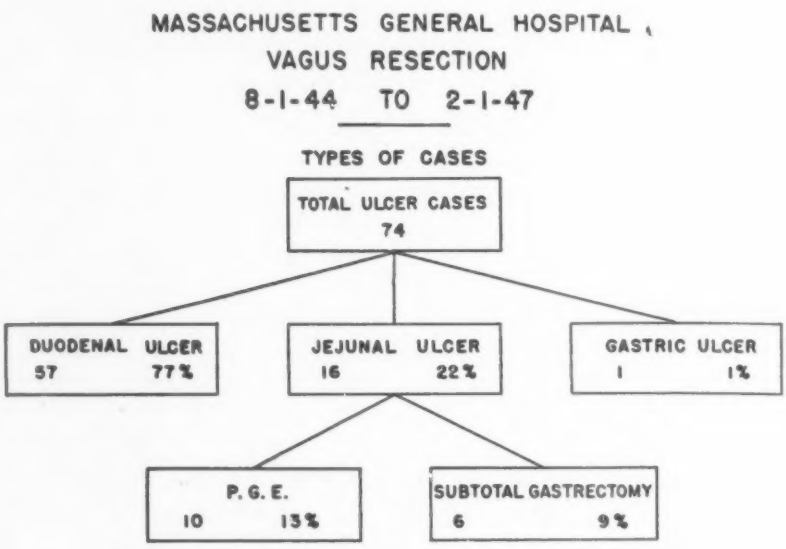

FIG. 1.—Types of ulcer cases treated by vagus resection.

The histories of a few patients who are classified as having *"fair"* or *"poor"* results may be helpful in understanding what is meant by these classifications.

CASE REPORTS

Case 1.—M. G. H. Unit #390253. This patient first presented himself at the hospital three years ago at the age of 22. . . . He was studied in the Out Patient Department because of the presence of ulcer symptoms and a demonstrable duodenal ulcer by x-ray. In July of 1945 the patient was admitted to the hospital because of intractability of his symptoms. It was found that there were many factors in this patient's background conducive to conflict, environmental and psychologic factors which might well be of considerable importance. Because of his lack of obstruction and the presence of an active ulcer, he was considered a good patient for vagus resection. However, the Psychiatric Service felt they might be able to help the patient and for that reason he was admitted to the Psychiatric Service and treated intensively for approximately three weeks. At the end of this time he had healed his ulcer and the patient was symptom-free.

Following discharge, the patient remained well for a month and one-half, at which time, having returned to the situation at home in which there were many difficult social and financial factors, the patient's ulcer pain returned. The patient noticed that his pain was made worse by worry, spices, or rich food. He noticed slight red blood in his stools on several occasions, although he never had massive hemorrhages. Barium enema was negative. It was decided at this time that he should have a vagus resection and on 12.6.45 he had a transthoracic transdiaphragmatic vagus resection.

The patient's immediate postoperative course was marred by a transient episode of vomiting on the 9th postoperative day, possibly the result of advancing his diet too rapidly. However, he recovered from this and was discharged on the 16th postoperative day. X-rays at the time of discharge showed atony of the stomach and duodenum up to the ligament of Treitz in a fashion seen in other cases. The pylorus was not abnormally "spastic."

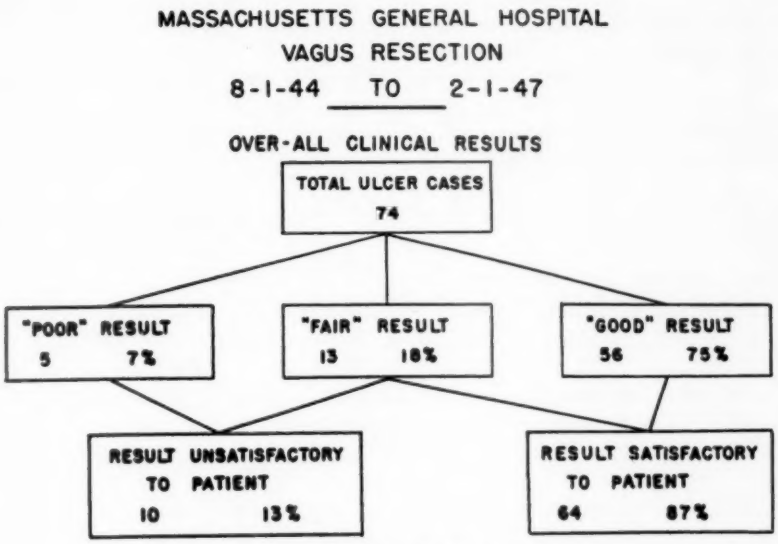

FIG. 2.—Overall clinical results.

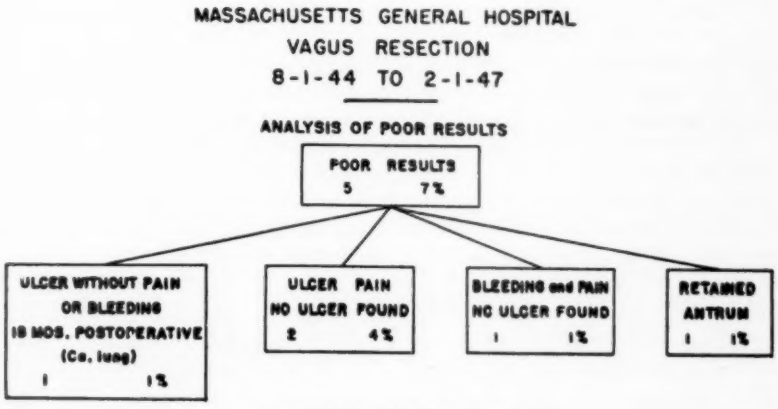

FIG. 3.—Analysis of "Poor" results.

Two days before leaving the hospital, but unbeknownst to his doctors, the patient began to develop diarrhea and for approximately four months the patient had an extremely intractable diarrhea, possibly the most severe diarrhea seen in this series. However, despite this diarrhea, he gained five pounds during this time and did not show gross disorders of his plasma chloride or nutritional disturbances. At the time his diarrhea was disappearing, he was re-x-rayed and still showed striking motility disorders in the stomach.

He was re-admitted to the hospital in May of 1946 for routine re-evaluation. At this

time his ulcer was still healed, the gastric picture was returning to normal by x-ray and he was gaining somewhat more weight. In September and November of 1946 he was seen in the clinic and each time showed some weight gain, but he had begun to have occasional "ulcer pains." He stated that they were mild and like hunger sensations. He had also noticed that under certain circumstances he had discrete short bouts of diarrhea again. However, he was at that time fairly well satisfied.

This patient's general comments on his recent questionnaire may cast some light on his problem. "Whether or not the operation was a success, I cannot say for sure. During the last month and one-half I have had much pain. Why is it that these pains come back? I have had to give up a very good position because of physical inability to do the work. My weight has not improved to any great degree. The more I think of things which are bothering me, the more I get pain. Even if I eat right away, the pain abates, but does not go away."

Here, then is a patient who must be classed as a *"poor"* result because of the return of pain which is similar to ulcer pain and who, in addition, had very disturbing diarrhea for a four-month period. In retrospect, the patient tends to discount the diarrhea, but regards his present pain as a major factor. His repeat x-rays for question of recurrence fail to reveal an ulcer crater.

Case 2.—M. G. H. Unit #479283. A 41-year-old patient who first presented himself at the hospital on 2.12.45 with a diagnosis of jejunal ulcer. The patient had a long and complicated ulcer history, including the performance of a posterior gastro-enterostomy which was later taken down and replaced in 1939 by an anterior gastroenterostomy. At the time of admission he had a large jejunal ulcer and was operated upon 2.26.45 at which time a vagus resection was carried out. The patient was discharged on the 11th post-operative day, completely relieved of his symptoms and remained an excellent clinical result until June of 1946, approximately 15 months postoperatively. Throughout this period the patient reported frequently to clinic, re-entered the hospital twice for routine kymographic and acidity studies and remained one of the dramatic results in the series. In June of 1946 the patient overimbibed alcoholic beverages and was admitted to another hospital with acute hemorrhage from the gastro-intestinal tract which subsided quickly on therapy and bed rest. The bleeding was not massive and the patient was never in shock. He signed out against advice from the other hospital and returned to our care on 1.2.47 for study. At this point he was approximately 21 months postoperative. He was well at this time, had no symptoms of ulcer. He had no jejunal ulcer by x-ray, though there was one area of slight stiffening of the jejunum. The patient had an inguinal herniorrhaphy at this time, was followed in the clinic and has remained well.

This patient remains a good result as far as the patient himself is concerned. He must be included in the *"poor"* results because he had an episode of bleeding which was presumably due to ulcer. This emphasizes the critical nature of this classification. We must presume him to have had difficulty with ulceration unless definitely proven otherwise.

Case 3.—M. G. H. Unit #433311. A 42-year-old patient who first presented herself at the hospital on 1.11.44 with the diagnosis of Raynaud's disease, hiatus hernia, esophageal ulcer and duodenal ulcer. This complicated situation was treated by vagus resection carried out 8.4.44. She was the second patient to be operated on at this hospital by vagus resection. Vagus resection was chosen because it was felt that it might control both the esophageal and duodenal ulcers, although all concerned realized that a new operation was being applied to a rather complex situation.

The patient's postoperative course was good for the first few months. However, after this time the patient began to complain of intermittent symptoms of fulness and had the symptom of regurgitation up her esophagus which bothered her tremendously. She returned to the hospital on 4.16.45 because of diarrhea and abdominal cramps. At this time obstruction to the outlet of the stomach was not striking and while in the hospital the patient's gastro-intestinal symptoms were mild. However, her Raynaud's disease was bothering her considerably so bilateral dorsal sympathectomies were carried out. Following this the patient was seen in the clinic and had a variable clinical course. X-rays taken at one point showed a recurrence of the esophageal ulcer; at a later occasion this could not be found. No clearcut recurrence of the duodenal ulcer was ever found, though in January of 1947, approximately 30 months postoperatively, the patient was very ill at home with a bout of vomiting which, in one day, changed from coffee grounds to bright red blood, with difficulty in swallowing. This picture passed off spontaneously in about one week, at the end of which time the patient came to the hospital, x-rays were taken, again no ulcer could be found, and there was no significant obstruction.

This is a patient whose checkered career postoperatively and the presumed recurrence of ulcer with bleeding makes it necessary to include her in the *"poor"* result group. Not only is she a poor result from the standpoint of the physician, but she herself is poorly satisfied with the results of her surgery. In retrospect, it is probable that a subtotal gastrectomy might have given her a better result, though some of her esophageal symptoms might have persisted even under those circumstances.

Case 4.—M. G. H. Unit #502947. A 31-year-old patient first admitted to the hospital on 9.5.45 with a five-year story of duodenal ulcer with some symptoms of vomiting, treated unsuccessfully by an internist, with periods of hospital management. Vagus resection was carried out on 9.20.45 and the patient left the hospital on the 9th postoperative day, having had an exceptionally smooth course, taking a satisfactory diet. On 2.22.46, approximately five months postoperatively, the patient returned to the hospital because of vomiting and a presumptive diagnosis of pyloric obstruction was made. However, x-ray showed that obstruction was not at the pylorus but instead in the third portion of the duodenum at the point where the mesenteric vessels crossed the bowel. The duodenum up to this point was quite widely dilated. The patient did well while he was in the hospital, took satisfactory diet without vomiting, returned home and was well for three more months until 5.11.46 when he returned with the same syndrome, both symptomatically and by x-ray. Treatment with acetyl beta methyl choline was unavailing and, therefore, on 5.17.46 a posterior gastroenterostomy was carried out, since which time the patient has been well, at work, gaining weight, and satisfied with the result.

This patient is included in the *"fair"* results, in the subgroup of those in which the final result is satisfactory to the patient. He cannot be considered a good result because of the development of symptoms which required additional surgery. His present status is satisfactory.

Case 5.—M. G. H. Unit #344702. This patient was first seen in this hospital in 1942 at the age of 42 with duodenal ulcer and a colloid goiter. She had a subtotal thyroidectomy with an uneventful convalescence. In 1946 she again entered the hospital with duodenal ulcer this time complicated by uterine bleeding of unknown source. At this point it was noted that her ulcer had not done well on medical treatment. She was treated for her endocrine difficulty and given a six-meal bland diet and creamalin for her ulcer pain. She was re-admitted four months later in July of 1946 with still further bleeding and intensification of her ulcer pain. Because of the fact that her uterine bleeding had not

been controlled by endocrine therapy, a total hysterectomy was carried out. Her ulcer pain continued as an extremely intractable type of symptom. It was noted that her ulcer symptoms were related to the deplorable situation of her home affairs and in her marital relationships. As a personality, the patient appeared to be mildly psychoneurotic, most strikingly so when she was having severe pain. At times when she was free of pain she was pleasant and agreeable, and seemed to have a rather good insight into the nature of her difficulties. On 8.15.46 a transthoracic transdiaphragmatic vagus resection was carried out. The patient showed no difficulty in getting up to a proper diet. An x-ray 12 days postoperatively showed typical changes in gastric motility, but were otherwise not remarkable. She began to have diarrhea at the time she left the hospital, but she had been free of pain throughout her short postoperative course.

She was re-admitted to the hospital, however, about one week later because of a severe exacerbation of her diarrhea, up to 12 to 14 movements a day. She was treated with belladonna and tincture of opium as well as a constipating type of diet, and improved to some extent, so that two months later she was having only one or two bowel movements a day but still had a "nervous feeling" in her stomach.

The answers to her questionnaire indicated that she had had some ulcer pain postoperatively whenever she took medicine for her diarrhea. Her chest pain was a minimal factor. She had feelings of indigestion and fullness with gas and belching. She had no vomiting. She regarded these symptoms as a major factor and deterrent to the effect of the operation. Her diarrhea remained a problem which came and went, apparently related to emotional strain. She also had trouble sleeping at night. She stated that although her ulcer pain was better since the operation, the other symptoms which she had acquired constituted a serious disturbance.

This is a patient in whom the gastro-intestinal side-effects of the operation constituted a major drawback to her operative result and in whom only a *"fair"* result can be claimed.

2. SIDE-EFFECTS OF THE OPERATION

a. *Diarrhea.* The most common gastro-intestinal side effect of this operation is diarrhea. We did not realize the frequency of this symptom until the present questionnaires were sent to the patients. Many patients have diarrhea of such a minor and transient sort that they do not remember to mention it at their office or clinic visits. However, in filling out a questionnaire in which there were several questions concerning diarrhea, it was of interest to observe that over half of the patients who have had vagus resection have had significant diarrhea at some time or other during their postoperative career.. There is no clear-cut correlation between the presence of diarrhea and the presence or absence of a gastro-jejunal stoma. It has been our experience that the diarrhea is usually associated with poor gastric emptying. One rather dramatic instance showed up the relationship between these two. This is a patient who had a dilatation of the stomach postoperatively. At the time his gastric dilatation disappeared the patient stated that his stomach felt better and that he was "putting things through." These feelings were associated with a striking decrease in his gastric residual. On the same day that his stomach began to empty he began to have diarrhea—six or seven movements a day—which lasted for four or five days. Many other patients have given the story that at the time they have diarrhea, they also feel distended, may have pain in the tip of the left shoulder, indicating diaphragmatic irritation, and often tell

of the eructation of offensive-smelling material. This would suggest that the diarrhea is a colonic manifestation of intermittent gastric emptying interspersed with periods of gastric stasis. Evidence indicating that in some cases it may be an "ulcer-equivalent" is presented below.

All these facts taken together might lead one to expect that performing posterior gastro-enterostomy in these patients would lessen the incidence of diarrhea, or that the pre-existing presence of a gastro-jejunostomy would decrease the incidence of diarrhea. However, this is not the case. The 19 patients in our series who have had pre-existent or concomitant jejunal stoma

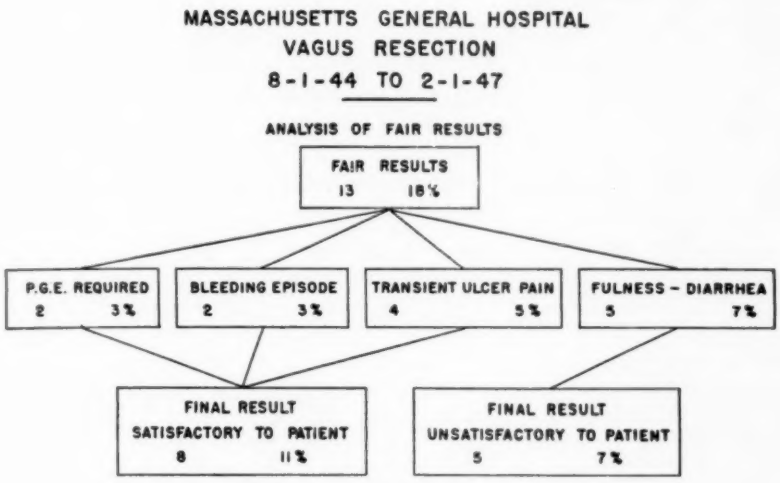

FIG. 4.—Analysis of "Fair" results.

have had as much diarrhea as the others and in many cases suffered the same epigastric distention and sensation accompanying the diarrhea, as shown in Figure 5.

In evaluating diarrhea from the patient's point of view, one may divide the phenomena into three categories:

1. Minor transient diarrhea which is referred to by the patient as "of no consequence" (48 per cent of the cases).
2. Diarrhea which constituted at some point a major problem but which disappeared or was diminishing at the time the patient was surveyed (8 per cent of cases).
3. Diarrhea which constituted a major problem, a symptom as important to the patient as his ulcer and whose presence detracted in a major way from the result of the operation. (6 per cent of cases). Figures based on this classification are shown in Figure 6.

b. *Emptying Disorders.* The next common disorder of the gastrointestinal tract found in these patients may be described as "fulness." This symptom may consist of either a mild feeling of discomfort after eating a heavy meal, as is so commonly experienced in patients who have had a subtotal

gastrectomy, or frequent eructation (often of foul-smelling material), pain in the left shoulder or, in one or two cases, actual visible epigastric bulging. This is in every way a less significant symptom than diarrhea and in most patients was taken as a matter of course, and was transient.

Here again, these symptoms may be divided into three grades:

1. Transient fulness (56 per cent of cases).
2. Fulness and eructation continuing and still bothering the patient (5 per cent of cases).
3. Fulness with vomiting, constituting a major problem detracting from the end-result of the operation (8 per cent of cases).

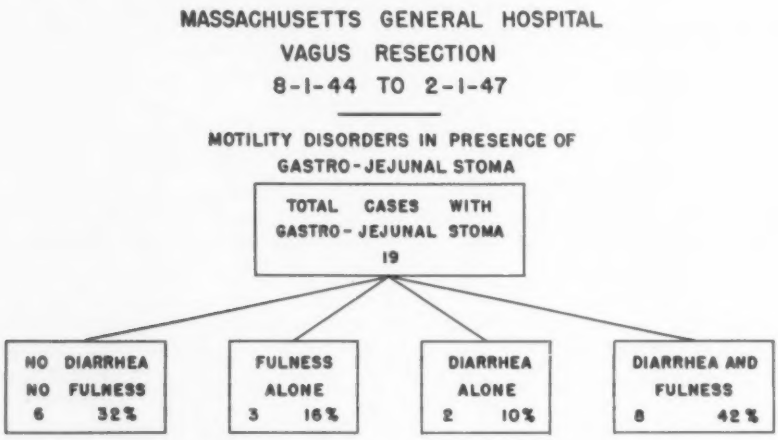
MASSACHUSETTS GENERAL HOSPITAL
VAGUS RESECTION
8-1-44 TO 2-1-47
MOTILITY DISORDERS IN PRESENCE OF GASTRO-JEJUNAL STOMA
TOTAL CASES WITH GASTRO-JEJUNAL STOMA 19
NO DIARRHEA NO FULNESS 6 32%
FULNESS ALONE 3 16%
DIARRHEA ALONE 2 10%
DIARRHEA AND FULNESS 8 42%

FIG. 5.—Motility disorders in the presence of a gastro-jejunal stoma.

Figure 7 shows classification based on the above. As in the case of diarrhea, a gastrojejunal stoma is no solution to the difficulty, as shown in Figure 5.

c. *Wound Pain.* The third category of difficulties which may be experienced by patients who have had this operation is pain in the chest incision. One must recall that most major thoracic surgery is done for malignant disease or crippling cardiac or pulmonary disease in which incisional pain recedes into the background as a minor side-effect. In a patient with duodenal ulcer, especially if it has been a painless ulcer which has bled in the past, any sort of discomfort or pain is magnified in the patient's mind and becomes a major problem. The situation is analogous in every way to the incisional pain experienced by patients with hypertension. It must be regarded in a very different light from the incisional pain of patients who have been operated on for cancer.

In this series of patients incisional pain of a major sort was extremely rare. This is a series of cases operated on almost wholly by the thoracic route. In all of the transthoracic operations the rib was resected. There were no intercostal incisions. In the questionnaire sent to the patients, full opportunity was given them to express their thoughts concerning incisional pain. They

were quite frank in expressing their reactions relative to diarrhea and other side-effects of the operation, and there is every reason to believe that they would be frank and straightforward in their comments about the incision. It is therefore, of interest and significance to find that only two of the entire group stated that incisional pain had ever bothered them more than to a very minor extent (Fig. 8).

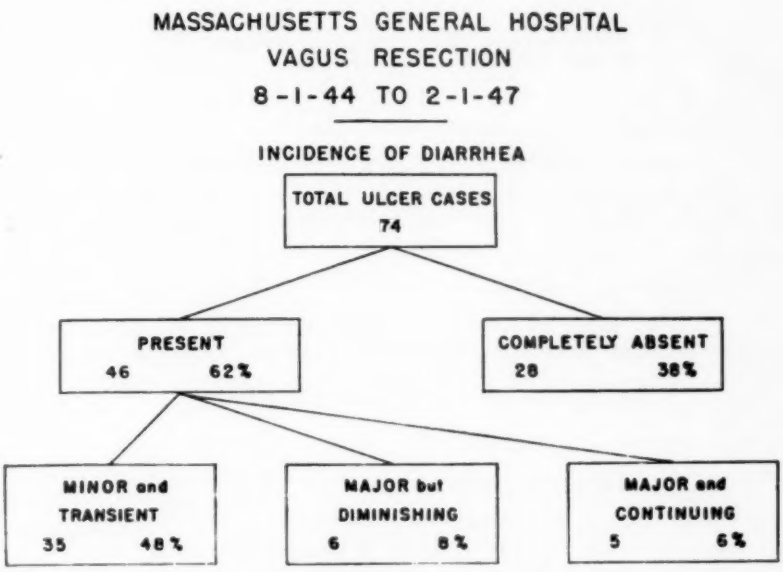

FIG. 6.—Incidence of diarrhea.

Early ambulation and early motion of the arm are of importance in avoiding incisional pain. If the arm is splinted or put in a sling, or if the patient is allowed to favor it excessively for several days, a stiffness and immobility of the shoulder joint ensues which is often the source of considerable discomfort weeks or months later.

d. *Miscellaneous Symptoms.* There is one type of symptom experienced by patients who have had this operation which is of interest though it is rarely very bothersome to the patients; it is a symptom concerning which future research might be rewarding. This is a symptom which we have termed "nervous loading." It consists of a feeling of nervousness and of unspent nervous energy of an uncomfortable sort which the patient experiences at times when previously his ulcer would have bothered him. Having observed such symptoms, the author questioned many of his patients as to whether or not they had observed "ulcer-equivalents" in their postoperative activities. Two patients stated that the distention-diarrhea syndrome was a clear-cut "ulcer-equivalent" in their case. When they found themselves in a situation which formerly had produced epigastric burning and ulcer symptoms, they now noticed epigastric fulness and mild diarrhea.

The suggestion may be made that vagus resection, by "damming up" one source of cholinergic outflow from the midbrain, may produce some other disease in its stead. Candidates for such diseases, that have been mentioned,

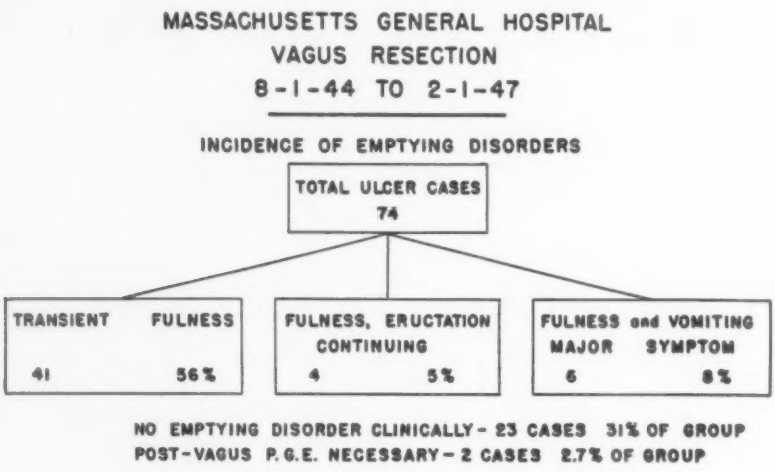

FIG. 7.—Incidence of emptying disorders.

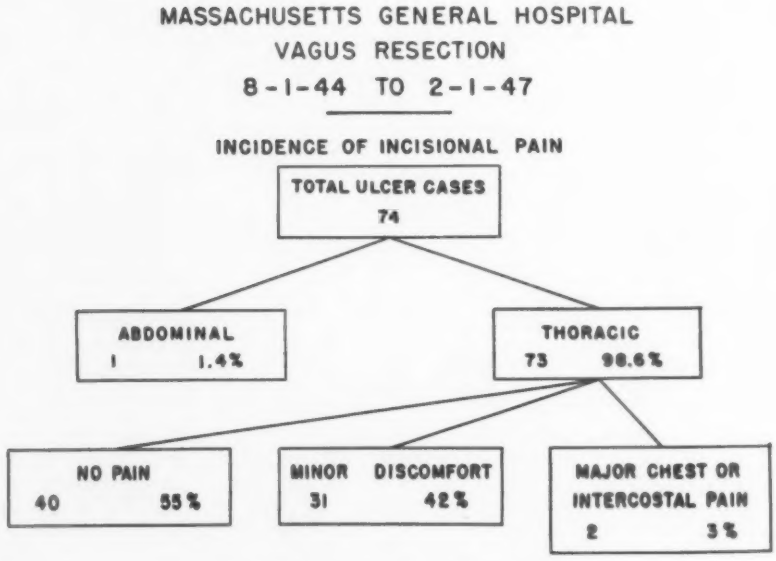

FIG. 8.—Incidence of incisional pain.

are ulcerative colitis, bronchial asthma, thyrotoxicosis, and other so-called psychosomatic diseases. To date none of these diseases has developed; yet the "nervous loading" symptoms may be an expression of the outflow of pent-up emotional energy which previously found its vent in the ulcer syndrome.

3. DISCUSSION

Vagus resection for ulcer is at the crossroads. That it is an effective weapon in dealing with ulcer is well known. We now know the approximate magnitude of its side-effects, if not of its failures. From this time forward we must try to balance its significant advantages against its shortcomings so that we may arrive at an evaluation of lasting significance.

The enigma involved in evaluating this operation is best illustrated by the comments of patients themselves. Some of the patients are admirably satisfied by this apparently simple and physiologic solution to their difficulties. Other patients have had a great deal of trouble from side-effects and would lead one to adverse conclusions. Possibly at the risk of introducing unscientific, though colorful material, we might quote a few of the comments which patients have made in association with their questionnaires.

M. G. H. Unit #454977. Male, age 36, duodenal ulcer 30 months postoperative:
"I have never felt better than I have for the last two years. I have even enjoyed my food, worked as hard as ever and I have had no pain at all."

M. G. H. Unit #480224. Male, age 62, jejunal ulcer 22 months postoperative:
"So far the operation shows signs of being successful. I get pains in my back now and then, but not to any great account. I am able to eat anything without any distress."

M. G. H. Unit #488327. Male, age 55, duodenal ulcer, 20 months postoperative:
"I am bothered with gas under the scar on the right side. I take one teaspoonful of powder after my breakfast and supper."

M. G. H. Unit #381380. Male, age 41, duodenal ulcer 18 months postoperative:
"Considering the agonizing pains previous to the operation, I now feel the operation of vagus resection for ulcer is a great feat."

M. G. H. Unit #501746. Male, age 38, jejunal ulcer 16 months postoperative:
"The only thing I can complain about is gas. Sometimes after I eat I have a feeling of fulness, discomfort, and vomiting. If I cut down on my meals, I find I will not be so apt to have it. My general health has been very, very good and I am certainly free from ulcer pain."

M. G. H. Unit #193174. Male, age 31, duodenal ulcer 12 months postoperative:
"For about three or four weeks after the operation I had trouble swallowing food. It always felt as though I swallowed wrong, but that condition disappeared. For about nine months I had a pain in the left side of my neck. I now weigh around 148 pounds as to 135 before. I eat everything, drink anything with no ill effects."

M. G. H. Unit #488323. Male, age 35, duodenal ulcer 12 months postoperative:
"For about three weeks after I came home I had the diarrhea. Our family doctor gave me two different kinds of medicine, the name of which I don't recall. It took about three weeks before it stopped. It was so bad that water would go right through me. Then when that stopped, I started vomiting about once a day, sometimes twice a day. This gradually got better. It took about two months for this to get better. My back never bothers me at all. It felt numb for a while and for quite a while after I went back to work, I used to get sick to my stomach every time I would do any stooping, but right now I never felt better in my life. I have never had any of those ulcer pains any more."

These fragmentary quotations illustrate the hesitancy which one must exercise before assigning a "good" result to a patient simply because his ulcer symptoms have disappeared.

If one treats a man of forty, suffering from an unobstructing painful duodenal ulcer, by subtotal gastrectomy, he is deliberately turning his back on the possibility that an excellent result may be produced by a simple physiologic procedure which does not interrupt the continuity of the gastro-intestinal tract. The surgeon is also assuming the risk of a hospital mortality, which, while low is far from negligible. He may also encounter complications relative to function of the stoma, nutritional difficulties, anemia, "dumping" syndrome and other side-effects of gastrectomy which are every bit as bothersome to the patient as the side-effects of vagus resection.

In the last analysis, vagus resection must compete with su tal gastrectomy as the operation of choice in intractable ulcer. As time go s by, we can hope that critical analyses of the side-effects and failures of subtotal gastrectomy will become available in increasing numbers.[3] The literature on subtotal gastrectomy has perforce often dealt with hospital mortality,[4] or the laboratory rationale of the procedure.[5] Unfortunately, neither of these considerations are particularly appropriate in comparing the operation with vagus resection. The hospital mortality of subtotal gastrectomy will probably always be higher than vagus resection, providing both operations are essayed by surgeons of comparable training. This condition arises simply from the fact that in vagus resection the gastro-intestinal tract is not entered or transected, and vagus resection is not applicable to those types of ulcer which produce much of the gastrectomy mortality rate such as acute massive hemorrhage or advanced cicatricial obstruction.

The low mortality of vagus resection cannot alone justify its performance. The operation must be able to show results which are as good as or better than subtotal gastrectomy in order to replace the latter. It is unlikely that in any large series of cases posterior gastro-enterostomy can be performed with or following vagotomy without somewhat increasing the hospital morbidity and mortality from the vagus resection.[6] If this is the case, one would again be led away from gastro-enterostomy as an adjunct to vagus resection.

Possibly vagus resection will finally come to occupy the role of a "clean-up" procedure to put to right the failures of other forms of surgery. This is a view with which the author is not in agreement. If vagus resection can stand on its own merits, it will have usefulness. If it has failures, those failures will most likely occur in patients who have had gastro-enterostomy, either with or without subtotal resection. Therefore, vagus resection used to "clean-up" the jejunal ulcers following other procedures, while of temporary benefit, may not be of lasting worth. The use of vagus resection as a secondary procedure will stand or fall wholly upon this consideration: is vagus resection a sound procedure for ulcer by itself, unaided and unhindered by previous or subsequent gastric surgery?

Careful work in several clinics has now been going on for a period between three and four years.[7-15] The perspective of time will be needed to help us make a decision as to the final place of this operation. Its injudicious perform-

ance for gastric ulcer, the indiscriminate use of gastro-enterostomy with the procedure, hasty operative technique with inadequate section of the nerves, and operation on patients who are inadequately studied and inadequately followed, are all to be condemned as features which will prolong the difficult phase of evaluation of this operation. The statement has been made that "vagotomy is not an experiment that should be undertaken simultaneously in many quarters."[16] This statement is most assuredly a wise one. It is hoped that in those quarters where vagotomy is not being studied, the results of subtotal gastrectomy may be evaluated in the same critical fashion that the results of vagus resection have been studied, with an eye towards the symptomatic end-result, so that the comparison of subtotal gastrectomy with vagus resection may be facilitated.

SUMMARY

1. The results of vagus resection for ulcer carried out in 74 cases have been described.

2. Satisfactory results have been obtained in approximately 90 per cent of the cases.

3. A poor result may be due to difficulty with ulcer, but may also occur when the side-effects are of a massive and crippling type; the minor gastro-intestinal side-effects are not vitiated by the performance of gastro-enterostomy.

4. Good results have been obtained in patients who were intractable to all other forms of therapy including subtotal gastrectomy.

5. Vagus resection is an addition to the surgical armamentarium which may come to occupy a permanent and important place.

6. A reserved attitude must be maintained until the present groups of patients have been followed longer.

7. The routine performance of posterior gastro-enterostomy coincident with vagus resection may so confuse results that in the future one will not know whether to assign the end-result, whether good or bad, to the gastro-enterostomy or the vagus resection.

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A STUDY OF THE RESULTS, BOTH FAVORABLE AND UNFAVORABLE, OF SECTION OF THE VAGUS NERVES IN THE TREATMENT OF PEPTIC ULCER*

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DRAGSTEDT'S REPORT IN 1946 on the section, with favorable results, of the vagus nerves in 54 cases of peptic ulcer, and similar reports by Grimson,† Ruffin and co-authors[4, 5, 13] concerning 30 such operations at Duke University, and by Moore and his associates concerning 12 cases in which the operation was carried out at the Massachusetts General Hospital, led us to study the

TABLE I
COMPARATIVE STATISTICS OF REPORTED VAGOTOMIES: YEAR 1947

		Performed for ulcer, type					
		Duodenal		Gastrojejunal		Gastric	
Reporter	Cases	Number	Per cent	Number	Per cent	Number	Per cent
Dragstedt	170	147	87	15	8.8	8	4.7
Walters and associates	83	54	65	24	28	5	6
Walters (alone)	40	28	70	7	17	5	12
Grimson	57	32	56	9	15	4	7
Moore	74	57	77	16	22	1	1

problem of section of the vagus nerves or, as we prefer to call the operation, "gastric neurectomy," from the anatomic, physiologic and chemical standpoints among 40 patients operated on by one of us (Walters) at the Mayo Clinic up to January 15, 1947 (Table I). Only brief reference will be made to a control series of 43 additional cases in which the operation was performed by other surgeons at the clinic, for the surgeons in question will individually report on their results in detail later.

HISTORICAL ASPECTS

Denervation of the stomach in the treatment of pain in peptic ulcer has been extensively investigated since Brodie's first report in 1814. Indeed, the operation has been performed in rabbits to assist in the experimental formation of gastric ulcers.

* Read at the meeting of the American Surgical Association, Hot Springs, Virginia, March 25 to 27, 1947.

† In Grimson's most recent report on the results of the operation in 57 cases, he described disturbances in motility in 25. In six cases there was severe gastric retention which necessitated gastro-enterostomy. This gave an incidence of secondary gastro-enterostomy in one among each seven patients who had not had a previous drainage operation.

Reports in the literature are extensive and confusing. Time permits only the briefest reference to some of the most important clinical and experimental studies. One of the most interesting reports is that of Latarjet[9] in 1922. His studies are worthy of evaluation in view of the fact that he and Pauchet performed the operation on six patients who had gastric ulcers, after they had carried out extensive experimental studies on the effects of section of the vagus nerves of dogs.[8] In commenting on the results of the operation in six, Latarjet stated that all were relieved of their symptoms and that they had gained in weight and appetite. Gastro-enterostomy had been performed for all of them at the time of the denervation procedure, but one died later of carcinoma of the stomach.[9]

No additional reports by Latarjet or his associate, Pauchet, are found in the literature regarding later results of these operations.

McCrea, after confirming the experimental work of Latarjet, stated, however, that Lichtenbelt had found gastric ulcerations in 70 per cent of his dogs after complete section of all of the parasympathetic and sympathetic branches of the vagus nerves. In 1931 Beaver and Mann found that after performing the Mann-Williamson operation on dogs, ulcers formed in two of the three dogs of the series despite previous section of the vagus nerves. Recent studies by Grindlay and Bollman seem to confirm the results of earlier studies by Beaver and Mann. In addition, Grindlay and Bollman produced peptic ulcers by the administration of cincophen. They found that ulcers developed whether or not the vagus nerves were sectioned, although the vagectomized dogs maintained a better nutritional state and lived longer, on the average, than did the control animals.

The preliminary studies of Saltzstein, Sandwerss, Hammer and Hill, recently presented, would indicate that, after section of the vagus nerves in dogs on which the Mann-Williamson operation was performed, jejunal ulcers developed in four of nine animals who died within 41 days following operation. Six of the nine had marked jejunitis.

In 1929 Hartzell studied the effects on dogs of section of the vagus nerves. Although the immediate observations were similar to those noted among human beings, when Vanzant studied the dogs two-and-a-half years later she found that free hydrochloric acid had returned to the gastric secretion in all but one of the original group. Some of the dogs still had delayed emptying of the stomach, but two of the dogs had hypermotility, with a tendency toward diarrhea and emesis. Later studies revealed the gastric motility to be essentially normal.

ANATOMIC STUDIES

In studying the problem, we thought it essential to determine the anatomic distribution of the vagus nerves immediately above and below the diaphragm. Hence, dissections were carried out in our department of pathologic anatomy on 56 men, 44 women and 11 children during the course of postmortem examinations.

In 92 of the specimens from adult persons studied at necropsy a rather regular pattern was followed in the formation of discrete nerve trunks from the esophageal plexus. In eight cases it was impossible to isolate two distinct trunks at any point, since the branches were numerous and did not have a uniform pattern.

These anatomic studies indicate, therefore, that excluding the 11 cases in which the vagus nerves of children were dissected out, the vagus nerves can be located and successfully sectioned near the diaphragm in approximately 92 per cent of the cases, and possibly most, if not all, of the branches in the remaining 8 per cent of cases can be sectioned by either a transabdominal or a transthoracic approach.

GASTRIC NEURECTOMY WITHOUT OTHER GASTRIC OPERATIONS

It is our belief that the transabdominal approach is preferable to the transthoracic one because it permits exploration of the contents of the abdomen, examination of the ulcer, removal of the ulcer if this is thought to be advisable, and the performance of a gastric drainage operation, such as gastroenterostomy, or partial gastrectomy independent of, or coincident with section of the vagus nerves.

In only 14 of the 40 cases did we believe that the operation of section of the vagus nerves could be done without other surgical procedures on the stomach in order to prevent serious postoperative gastric retention. In 13 of the 14* cases, results have been satisfactory as measured by relief of pain, reduction of acidity, and in general by reduction of gastric secretions. Ten of these operations were performed for duodenal ulcer, two were performed for gastric ulcer and two for gastrojejunal ulcer.

Of the ten patients who had duodenal ulcer, eight obtained a reduction of gastric acidity. In four of them the reduction was to an achlorhydria. For eight of the patients the Hollander insulin test was carried out. Results of this test in six cases showed a flat or decreasing curve of secretion of gastric acids. Results of the test in two cases showed a rise in the secretion of gastric acids.

There were disturbances of motility, with gastric retention, in four (40 per cent) of the cases. One patient required intermittent aspiration from the 4th to the 9th postoperative day; the remaining three were found to have considerable retained secretion and an atonic stomach as demonstrated roentgenologically.

In two patients who had small gastric ulcers achlorhydria developed after the operation. Results of insulin tests were negative. In one of the patients an atonic stomach developed which continued for at least eight weeks. Although this patient was relieved of pain after his operation, he complained of discom-

* The 14th patient, a man 39 years old, with a severe vascular disease, died suddenly in the anesthesia recovery room one hour after transabdominal gastric neurectomy. The patient's ulcer pain had been intractable to treatment. The risk of the operation was appreciated. At postmortem examination almost complete occlusion of the coronary arteries was found, caused by both arteriosclerotic and atheromatous changes in their walls.

fort and a sensation of fullness in his stomach after he had eaten a small amount of food at meal time. At the time of his re-examination at the clinic, eight weeks after operation, the stomach was so dilated and there was so much secretion that the roentgenologist was unable to determine whether or not the gastric ulcer had healed. Unfortunately, gastroscopic examination was not made in this case, but will be done at the next visit of the patient.

Since this is the most important group of cases, because of the difficulty of evaluation of the effect of section of the vagus nerves if an associated gastric operation is done, it has been thought advisable to select an additional group of patients who also underwent only section of the vagus nerves by our surgical colleagues at the clinic. Whereas in all our cases the operation was done transabdominally, in 14 of their cases it was done transthoracically and in five cases it was done transabdominally.

CONTROL SERIES: VAGOTOMY ONLY

Transthoracic.—In the group in which the approach was transthoracic, five patients were operated on for duodenal ulcers and nine were operated on for gastrojejunal ulcers. Two patients who had duodenal ulcers and one who had a gastrojejunal ulcer obtained no reduction of gastric acidity. Postoperative roentgenologic studies of two of the nine patients (22 per cent) who had had gastrojejunal ulcers continued to disclose jejunitis. For one of these two patients a state of achlorhydria had been obtained, but no reduction of acidity occurred in the patient who had the duodenal ulcer. This patient also had considerable gastric retention.

Four of the five patients with duodenal ulcer had delayed emptying of the stomach; in one of the four this delay was so prolonged (two months) that anterior gastro-enterostomy was performed. The pylorus was found to be open, and the scar of the ulcer was present.* In spite of this, the patient continued to have a large degree of gastric retention for more than 30 days. Another patient with duodenal ulcer continued to have ulcer pain and nocturnal pain, requiring food and alkalies for relief. Two patients had troublesome diarrhea, one had a return of symptoms of ulcer and the other had nausea and vomiting in addition.

Transabdominal.—Two patients with duodenal ulcers and three with gastrojejunal ulcers underwent transabdominal gastric neurectomy. Only one of these patients obtained a good result, with complete relief of symptoms. One of the patients with a duodenal ulcer had symptoms of bloating, belching and vomiting four months postoperatively, and although he had no ulcer pain a roentgenogram disclosed a persistent duodenal ulcer.

One patient died after a convulsion on the 4th postoperative day. Unfortunately, consent for postmortem examination could not be obtained in this

* Since gastric neurectomy had been done transthoracically, the gross pathology of the duodenal ulcer could not be compared with its appearance at the time of gastro-enterostomy.

case. This patient had also undergone cholecystectomy and appendectomy at the time of section of the vagus nerves.

One of the patients with a gastrojejunal ulcer had persisting symptoms of ulcer. Disturbances of gastric motility required aspiration for one month after operation. The roentgenogram showed a poorly functioning gastroenteric anastomosis, with distortion of the jejunum, and the presence of a gastrojejunal ulcer could not be ruled out.

GASTRIC NEURECTOMY WITH GASTRIC OPERATIONS

Time does not permit a detailed discussion of studies of patients for whom gastric neurectomy and operations on the stomach were carried out simultaneously or later because of failure of the ulcer to heal or because of recurrence of the ulcer or because of persisting gastric retention. A detailed report of 26 cases will be made elsewhere.

Duodenal ulcer.—Suffice it to say at this time that among the 15 patients with duodenal ulcer on whom one of us (Walters) operated, performing gastro-enterostomy in addition to resection of the vagus nerves, a reduction of gastric acidity occurred in 11 (73 per cent), and in seven of these 11 (56 per cent) it reached the state of achlorhydria. Troublesome disturbance of gastric motility developed in four (26 per cent). In one patient with a large obstructing duodenal ulcer, such a marked degree of abdominal distention developed from the 5th to the 7th day that an intestinal obstruction was thought likely. Abdominal exploration revealed that the entire gastro-intestinal tract was filled with fluid and gas, and that 800 cc. of sterile straw-colored fluid was present in the abdominal cavity. The gastro-intestinal motility returned to within normal limits in a few days after continuous aspiration of the gastro-intestinal secretions by means of an indwelling gastric suction tube.

Another patient had intermittent gastric retention daily, in which the fluid retained sometimes reached a maximum of 2,000 cc., with gradual reduction in the amount until the 14th postoperative day. Six months later he reported by letter that the symptoms of ulcer had returned, and that vomiting had occurred.

Another patient reported by letter three months postoperatively that he had considerable flatulence and diarrhea which were not relieved by the usual measures, such as the taking of paregoric.

Gastric ulcer.—Three patients underwent excision of ulcer in association with gastric neurectomy. One patient was a man 67 years old for whom one of us (Walters) had performed removal of a gastrojejunal ulcer and a closure of his gastric and jejunal openings on June 14, 1946. He had a large gastric ulcer on the posterior wall of the stomach; the ulcer had perforated to the pancreas just below the esophagus. To have removed it would have necessitated a very high partial gastrectomy, and it was thought that the situation was one which should be suitable for transthoracic section of the vagus nerves. Six and a half weeks of medical treatment was administered after removal of the

gastrojejunal ulcer, but without benefit. Transthoracic section of the vagus nerves was carried out by Doctor Clagett and one of us (Walters) on June 29, 1946. In addition, the gastric ulcer was excised to exclude the possibility of malignancy. Although the immediate results of the operation seemed good—a state of achlorhydria was obtained as was also a negative result of the Hollander insulin test—within a period of a few weeks the patient began to complain again of abdominal pain. A roentgenogram at this time showed a recurrent large gastric ulcer in the same position as that of the ulcer previously excised. Concurrently, anemia appeared and free hydrochloric acid again returned to the stomach. The result of an insulin test was again negative, but high acid values for histamine stimulation were obtained. When resection of the stomach was performed, January 13, 1947, including removal of the large gastric ulcer (3.5 cm. in diameter), by our colleague, Doctor Waugh, the ulcer was reported as benign. Although the patient is out of the hospital, he reports that he is no better than he was before partial gastrectomy.

There was a second case in which a large gastric ulcer situated on the posterior wall was excised. The patient complained of frequent belching of foul gas four months after the operation. Roentgenologic examination showed a dilated stomach with so much secretion at the end of a five-hour period that the roentgenologist was unable to determine whether or not gastric ulceration had returned. Gastroscopic examination revealed no recurrence of the gastric ulcer. In this case, associated with the dilatation of the stomach, was hypomotility of the small intestine, with seeming spasm of the pylorus.

Gastrojejunal ulcer.—For one of the five patients operated on for gastrojejunal ulcers, re-resection of the stomach was performed in order to remove a large perforating anastomotic ulcer with its base on the colon. Removal of the gastrojejunal ulcers and closure of the openings of the stomach and jejunum were performed in the other cases, in two of which it seemed advisable because of the obstruction of the duodenum by the scar of the previous duodenal ulcer.

Among the patients who had gastrojejunal ulcers, immediate results of the operation have been very satisfactory.

CONTROL SERIES: VAGOTOMY ASSOCIATED WITH OTHER OPERATIONS

In the control series of 24 patients who underwent gastric neurectomy and additional gastric operations performed by our colleagues, 19 patients were operated on for duodenal ulcer and five for gastrojejunal ulcer. Most important in the group was a patient with duodenal ulcer who, after section of the vagus nerves and gastro-enterostomy, died on the 14th day. Although his postoperative course was characterized by marked gastric retention and hypoproteinemia which was difficult to control, the presence of the perforated ulcer and subdiaphragmatic abscess was not recognized until demonstrated at postmortem examination.

Resection of the stomach was performed for one patient who had a bleeding gastrojejunal ulcer. This patient had had transthoracic section of the

vagus nerves performed elsewhere six and a half months previously, without benefit.

Eighty per cent of the patients obtained marked reductions of gastric acidity, 36 per cent to an achlorhydric degree. Temporary disturbances of motility were present in five or 31 per cent of the cases. As in our series, the relief of symptoms was no different than it would have been had associated gastric neurectomy not been carried out.

SUMMARY

Our studies on section of the vagus nerves indicate that the results are inconstant, variable, and in most cases unpredictable. The relief of pain obtained is probably brought about by release of gastrospasm and reduction of gastric acidity as a result of the interruption of cephalic stimulation and as a result of other factors not now understood. The expense of this is dilatation of the stomach with frequent troublesome retention of gastric secretion and, in some cases, food remnants. Moreover, that relief of pain is not the result of healing of the ulcer must be considered, since in one of our cases an unsuspected acute perforation of duodenal ulcer developed. A similar case has been reported by Weeks and his associates.

Reduction in gastric acidity, although it has occurred in most cases, is inconstant in others, and disturbances of motility of the stomach and small intestine are of frequent occurrence after operation. In some cases such disturbances are temporary and in others they are prolonged, persistent and troublesome to the patient. In such cases, patients have complained of frequent belching of foul-smelling gas, a sensation of fullness and bloating after meals and, in a few cases, nausea and diarrhea.

In at least one clear-cut case the ulcer has been known to have recurred, and in the others the ulcers have failed to heal and reoperation has been necessary to remove the ulcers or to provide drainage of the stomach because of the troublesome gastric retention.

There have been three deaths in the hospital in the 83 cases. Although two of these could be attributed directly to cardiovascular accidents, one patient died of an unsuspected perforated duodenal ulcer with a subdiaphragmatic abscess. Gastro-enterostomy had been done in association with gastric neurectomy. Another patient died from coronary occlusion at home four months after closure of a gastrojejunocolic fistula.

In evaluation of the results of the operation, it must be proved that an ulcer is present and that the vagus nerves have been completely sectioned. It is our opinion that the best approach, in most cases in which gastric neurectomy is contemplated, is by means of a transabdominal incision, for such an approach allows both examination of the ulcer and exploration of the gastrointestinal tract and performance of such procedures as might seem necessary to supplement the gastric neurectomy. The greatest field of usefulness for gastric neurectomy seems to be in the treatment of ulcers after partial gastrectomy and in certain cases of nonobstructive duodenal ulcers in which the

cephalic phase of gastric secretion is marked and pain is intractable. If the operation is used in the treatment of gastrojejunal ulceration after gastroenterostomy the possibility of obstruction at the stoma and at the site of the healed or reactivated duodenal ulcer must be considered.

In view of the inherent ability of the gastro-intestinal tract of human beings, like that of the gastro-intestinal tract of animals in the experimental laboratory, to regain through anatomic and compensatory mechanisms its function after operative procedures which disturb neuromuscular continuity, and since restoration of gastric acidity and gastric motility has occurred within a two-year period in dogs in which gastric neurectomy has been performed, the possibility of such a return in human beings must be kept in mind constantly.

For the time being, the operation of gastric neurectomy must be considered to be in the investigative stage and the effects of the operation carefully studied.

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SECTION OF THE VAGUS NERVES TO THE STOMACH IN THE TREATMENT OF PEPTIC ULCER*†

Complications and End Results After Four Years

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DURING THE PAST FOUR YEARS, division or resection of the vagus nerves to the stomach as a method of treatment has been employed in the Department of Surgery of the University of Chicago on 212 patients with various types of peptic ulcer. One patient died of aspiration pneumonia, making an operative mortality of something less than one-half per cent. Although a careful watch was made, no gross evidence of any serious disturbance that could be ascribed to a vagus reflex was encountered. The theoretical background for employing this procedure in the treatment of peptic ulcer has been presented in previous publications from this clinic.[1] It is the purpose of the present communication to describe the complications and end results of vagus section for peptic ulcer in 160 patients who were operated on by us during the four years from January 18, 1943, to January 1, 1947. In these 160 patients, the vagus section was complete in 142 cases as evidenced by a reduction in the night secretion of gastric juice, a decrease of over 60 per cent in the total hydrochloric acid output from the stomach, and a negative secretory response to insulin hypoglycemia. Persistence or recurrence of ulcer symptoms has not been seen in any of these patients, and at the present time, all of them are free of ulcer distress without medication or any type of dietary restriction. In most cases, there is also satisfactory objective evidence that the ulcers have healed. In the 18 patients where physiologic tests have indicated that the vagus section was not complete, 13 have remained free of ulcer symptoms without medication or dietary restriction. In the remaining five, persistence or recurrence of ulcer symptoms in varying degree have been observed. In two of the patients, the symptoms were sufficiently severe so that our proposal for a reoperation was accepted. One of these patients had been operated upon by the transthoracic and one by the transabdominal approach. Reoperation in each case was done by the transabdominal method. In both instances, a remaining vagus fiber was found and sectioned. The results are summarized in Tables I and II. In three of the patients where recurrence of symptoms has been observed, these have been so mild that no treatment has been desired. The 13 patients in whom we

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have reason to believe that the vagotomy was incomplete, but who at present are free of ulcer symptoms without medication or dietary restriction, are being watched with great interest. It seems probable on the basis of present information that to be effective, the vagus section must be complete, and that recurrence or persistence of ulcer symptoms may occur if even a small vagus fiber to the stomach has been overlooked. This observation is of interest when correlated with the effect of vagus section on gastric secretion. Section of one of the vagus nerves in dogs has no effect on the volume, acidity, or total output of acid in the gastric secretion. In man, apparently the persistence of a small vagus fiber after section of two of the larger vagal trunks permits the continued excessive night secretion characteristic of the ulcer patient. The remaining vagus fiber appears to be able to activate the entire glandular apparatus, acting presumably through the submucous plexus of Meissner.

TABLE I

Patient J. S. Male Age 57
Five-year history of duodenal ulcer with two massive hemorrhages.

September 10, 1945	TRANSTHORACIC VAGOTOMY			
Night Secretion	Volume	Free Acid	HCl Output	Insulin Test
Preoperative.....	1,375 cc.	24	34 m.e.	Pos.
Postoperative.....	1,065 cc.	36	38 m.e.	Neg.

Patient entirely well in the interim, on full diet and without medication.

November 23, 1946 Silent massive hemorrhage.

December 12, 1946	TRANSABDOMINAL VAGOTOMY			
Night Secretion	Volume	Free Acid	HCl Output	Insulin Test
Preoperative.....	1,200 cc.	62	74 m.e.	Pos.
Postoperative.....	640 cc.	23	15 m.e.	Neg.

TABLE II

Patient L. H. Male Age 42
Six-year history of duodenal ulcer.

October 10, 1946	TRANSABDOMINAL VAGOTOMY			
Night Secretion	Volume	Free Acid	HCl Output	Insulin Test
Preoperative.....	970 cc.	13	13 m.e.	Pos.
Postoperative.....	858 cc.	29	25 m.e.	Pos.

Relief of symptoms for one month post-operatively. Then recurrence of all previous symptoms.

January 3, 1947	TRANSABDOMINAL VAGOTOMY			
Night Secretion	Volume	Free Acid	HCl Output	Insulin Test
Preoperative	870 cc.	18	16 m.e.	Pos.
Postoperative.....	410 cc.	0	0	Neg.

Where the vagotomy has been complete, there is to date no evidence of regeneration of the secretory fibers in the vagus nerves. Re-examination of these patients has been made at intervals by measuring the night secretion of gastric juice, the total hydrochloric acid output, and the secretory response to insulin hypoglycemia and the sham meal. Since an interval of three and four years has elapsed in a number of these patients, it seems quite probable that the nervous phase of gastric secretion has been permanently abolished. The evidence obtained from the experimental laboratory on the pathogenesis of peptic ulcer suggests that the ulcers will not recur unless the previous excessive secretion returns. The outlook is accordingly much more favorable than the present limited period of clinical observation would justify.

POSTOPERATIVE MANAGEMENT

The complications following gastric vagotomy for peptic ulcer have been for the most part transitory and inconsequential. In 61 patients, the vagus section was performed by a transthoracic operation. One of these patients developed an aspiration pneumonia which proved fatal. This was the only death in the series and occurred early in our experience. There have been no deaths in the last 150 vagotomies. A pleural effusion requiring aspiration was encountered in six patients. In no case did this effusion become infected. Intercostal pain in the region of the incision proved troublesome in ten patients, and in these, persisted for a period of two to four weeks.

Gastric Retention. It is probable that a delay in the emptying of the stomach occurs in all patients following section of the vagus nerves. This delay produced transitory symptoms in 19 of the 61 patients in whom a transthoracic vagotomy was performed. In four the gastric retention was severe enough to necessitate a gastroenterostomy within two or three months following the vagus section. In each of these cases, cicatricial obstruction at the pylorus was found. The necessity for a second operation in these four patients prompted us two years ago to explore the possibility of securing a complete vagus section by a transabdominal approach. The remarkable elasticity of the esophagus, which was appreciated in the transthoracic operation, suggested that it ought to be possible to pull the esophagus downward into the abdomen sufficiently to permit careful exploration of its lower three or four inches. We are now convinced that it is just as possible to secure a complete section of the vagus nerves to the stomach by a transabdominal operation as can be secured by the transthoracic approach. The method that we presently employ is best described in a series of diagrams and drawings (Figs. 1–4). We prefer the transabdominal operation at the present time because it is possible to deal with cicatricial obstruction at the pylorus at the same procedure. Of the patients who were operated upon by the abdominal route to January, 1947, in 64 cases, the abdominal vagotomy was accompanied by a posterior gastroenterostomy, while in 35 patients, a vagus section alone was performed. In the first patients, the gastroenterostomy was added as a routine in all patients with duodenal ulcer, but for the past year, it has been employed only when pyloric obstruction has been indicated either by clinical symptoms or fluoroscopic findings. At the present time, posterior gastroenterostomy is being performed in approximately one-third of the patients for whom a transabdominal vagus section is done for duodenal ulcer. In the 35 patients with duodenal ulcer in whom vagus section alone was performed, 19 patients displayed transitory symptoms of gastric retention. Two subsequently required a gastro-enterostomy because of cicatricial obstruction at the pylorus. Of the 64 patients in whom a gastroenterostomy was performed at the time of the abdominal vagotomy, eight patients showed transitory symptoms of gastric retention but have subsequently remained well.

Stomach Motility and Tonus. It is probable that more difficulty would have been encountered from the decreased tonus and motility of the stomach

produced by vagus section had its possibility not been anticipated and measures taken to prevent it. The stomach like the heart and the amphibian lung possesses a local automatism which is largely due to its relation to Auerbach's plexus. This makes it possible for the stomach to display its normal motility after all extrinsic nerves have been severed, or even after the stomach has been removed from the body. Under normal conditions, however, its activity is under the influence of two sets of extrinsic nerves. In general, the vagus nerves exert an inhibitory influence over the motor activity of the cardia, an

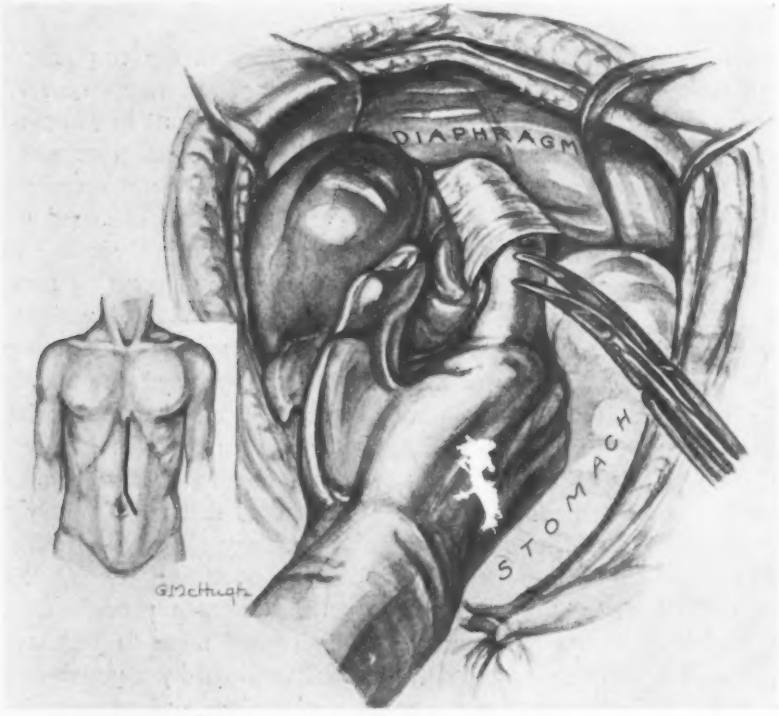

FIG. 1.—The abdomen is opened through a high left paramedian incision. The triangular ligament to the liver is divided.

augmenter influence on the body of the stomach, and an inhibitory influence on the pylorus. In general, the effect of the sympathetic is antagonistic to that of the vagus. A sudden removal of the tonic effect of the vagus nerves leaves the inhibitory influence of the sympathetics unopposed, and the end result is to cause a marked inhibition in the tonus and motility of the stomach. This makes the stomach very susceptible to the dilating effect of swallowed air or accumulated secretion, and if care is not taken, an acute dilatation can quite readily be produced. After a period of time which varies in different patients, a readjustment of the peripheral motor mechanism occurs, and the motility of the stomach returns toward its normal state. It is likely that it never regains the hypertonus and hypermotility so commonly found in ulcer patients. It has been

our practice to guard against distention of the stomach during the immediate postoperative period by maintaining gastric decompression by means of a Levine tube and the Wangensteen suction apparatus for a period of five days following the vagus section. This is perhaps the most important single item in postoperative care. After the five-day period, the patient is given small amounts of water, and at the end of 12 hours, the stomach is aspirated to

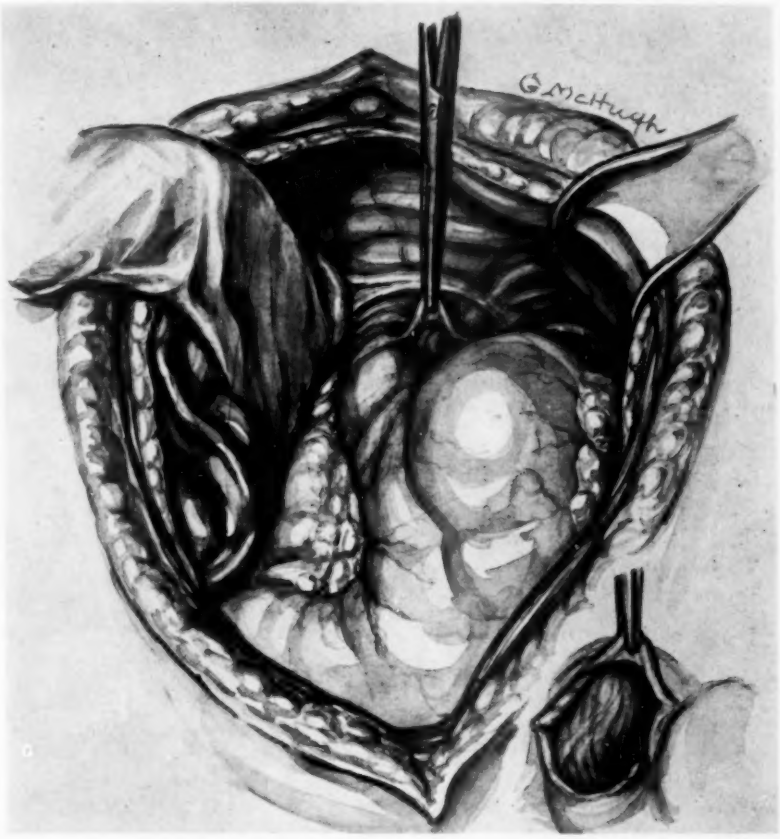

FIG. 2.—The left lobe of the liver is retracted to the right, and the peritoneum over the esophagus at the margin of the diaphragm is divided and the hiatus opened.

determine if retention has occurred. If the stomach is not emptied, decompression is instituted and maintained for another 24 to 48 hours. Only when the stomach empties itself satisfactorily of liquid content is the patient permitted to ingest solid food. The amount ingested at any one feeding is limited, and the patient is cautioned not to overload the stomach during the first two or three months after the operation. In several patients, we have felt that the return of function or readjustment of the peripheral motor mechanism of the stomach was facilitated by giving the patient ten mg. of urecholine from an hour to 30 minutes before the ingestion of food. This drug produces a long

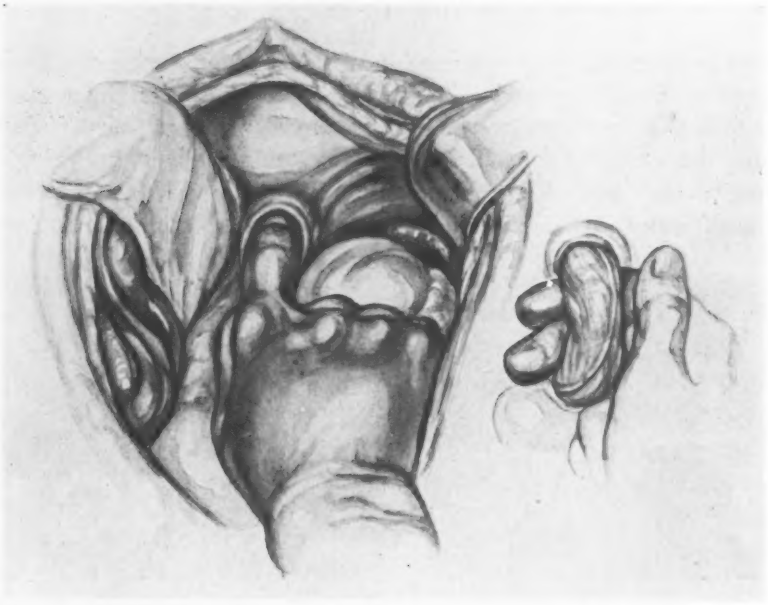

FIG. 3.—The finger is introduced over the esophagus into the mediastinum, the esophagus mobilized by careful finger dissection and pulled downward into the abdomen for a distance of 2 to 3 inches.

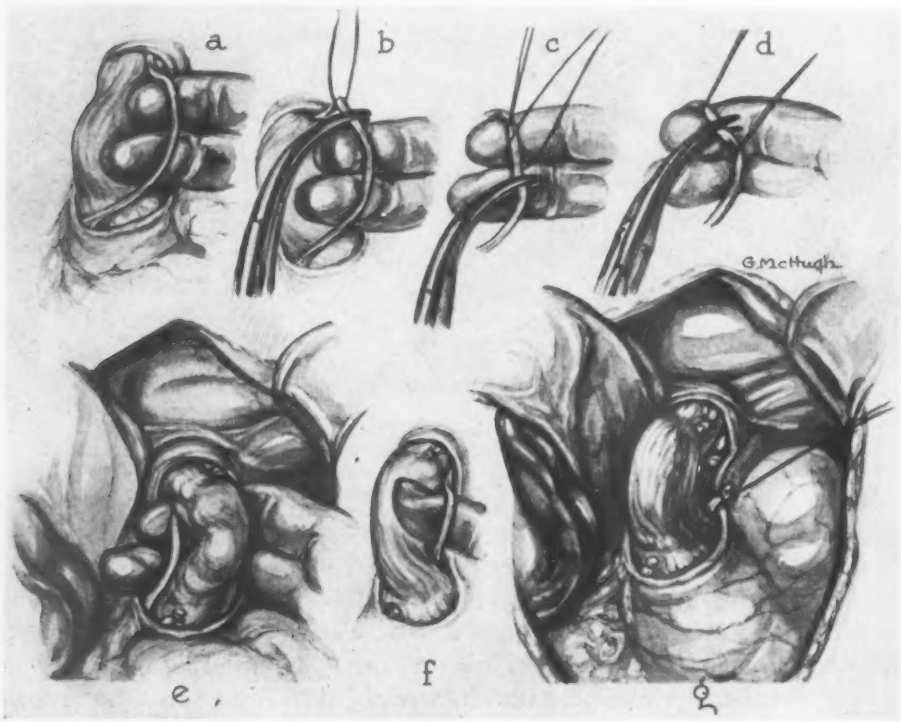

FIG. 4.—The vagus nerves are separated from the esophagus by finger dissection, ligated with nonabsorbable suture material, divided, and a segment 4 to 6 centimeters in length excised.

continued increase in the motility of the stomach probably through stimulation of the peripheral neuromotor mechanism. That this readjustment in gastric motility can be confidently expected is indicated by the fact that none of the patients who were operated upon by us during the first three years are at present experiencing any difficulty on this score.

Alteration in the bowel habit was encountered in 25 of the 61 patients who underwent transthoracic section of the vagus nerves. In 18 of these patients, the effect was slight and transitory and usually elicited only by question. In seven patients, however, there was a moderately severe diarrhea, in some cases lasting from two to five weeks after the operation. This diarrhea was usually episodic in character with frequent long intervals of freedom between attacks. There appeared to be an association between the diarrhea and symptoms of gastric retention. The cause of this diarrhea has not been fully determined. Since division of the vagus nerves removes the augmenter influence of this system from the tonus and motility of the small intestine and the proximal half of the colon, a change in the bowel habit in the direction of stasis or constipation was anticipated. To our surprise, this has not been encountered in a single patient. It is doubtful if the diarrhea can be ascribed to an increased motility of the small intestine and colon due to removal of vagal influences since it is most likely that this occurs in every patient who undergoes a partial or subtotal gastric resection. A consideration of the anatomy of the vagus nerves to the stomach makes it seem very probable that the usual type of gastric resection removes the vagus innervation from all structures below the stump of stomach that remains. The gastric contents following complete vagotomy usually contain no free acid during the digestive period when food is present in the stomach. The removal of the antiseptic action of the free acid of the gastric juice probably makes these patients more susceptible to diarrheas of bacterial origin. The situation here may be similar to that obtaining in patients with anacidity from other causes such as pernicious anemia. Retention in the stomach in combination with this anacidity makes fermentation possible and the consequent elaboration of various irritant organic acids. In the 64 patients with duodenal ulcer in which an abdominal vagotomy plus gastroenterostomy was performed, diarrhea, slight and transitory in character, was encountered in only four patients. Since gastric retention was less evident in these patients than in those with vagotomy alone, it seems likely that this factor is of some significance in the cause of the diarrhea. The diarrhea has usually subsided promptly when gastric decompression has been resumed. Spontaneous recovery from the diarrhea has usually accompanied readjustment of the motor activity of the vagotomized stomach and intestines, and none of the early patients are experiencing any difficulty on this account.

In the dog, section of the vagus nerves high in the chest or in the cervical region almost invariably produces a high grade and long continued spasm of the cardia and of the pylorus. For this reason, it is of great interest that we have not encountered spasm of the cardia in a single patient following vagus section. This is probably due to the fact that the vagi are usually

divided a short distance above the diaphragm. It is quite possible that damage to the vagus nerves higher up might produce spasm of the cardia in man as it does in the lower animals. In two patients, edema of the lower esophagus, probably due to the trauma of the operation, caused temporary dysphagia. The passage of the esophagoscope promptly gave relief without recurrence.

In summarizing our experiences with complete section of the vagus nerves to the stomach in the treatment of peptic ulcer, it appears clear that this operation, as we have described it, abolishes permanently the nervous phase of gastric secretion, and likewise removes the augmenter influence of the vagus nerves on the tonus and motility of the stomach and small intestines. It is probable that both the effect on gastric secretion and on motility exert a favorable effect on the healing of peptic ulcers. It is probable that the depressant effect on the secretion of gastric juice is the more important factor in bringing about the healing of the lesion. The decrease in the tonus and motility of the stomach probably also exerts a beneficial influence in the same direction, and undoubtedly contributes much to the relief of the distress which these patients experience. Both of these effects are likewise mainly responsible for the undesirable sequelae and complications of the operation. We should like to emphasize, however, that these complications in our experience have been self-limited, and for the most part inconsequential as compared to the complications that have been described following subtotal gastrectomy for peptic ulcer.

One of the most conspicuous effects of section of the vagus nerves to the stomach in patients with peptic ulcer is the immediate, complete, and apparently permanent relief of the ulcer distress that is produced. We have frequently called attention to this phenomenon which is so marked that in our early experience led us to speculate on the possibility that the stomach had been rendered anesthetic by the operation. Subsequent experience, however, has convinced us that this is not the case. In the operations that have been performed by the transabdominal route, the anesthetic has been for the most part continuous spinal. Under these conditions, mobilization, pinching, ligating, and dividing the vagus nerves have not produced any sensation. A more crucial experiment, however, has been performed on five patients who had very severe ulcer pain when they came to the hospital. In these patients, it was found that aspiration of the gastric content usually provided immediate relief. The reintroduction in the stomach of 200 cc. of .5 per cent hydrochloric acid solution caused an almost immediate reappearance of typical ulcer pain and distress. Following the operation, all of these patients were immediately and completely relieved. Usually on the third day following the operation, without the knowledge of the patient, the Wangensteen suction apparatus was discontinued, and 200 cc. of .5 per cent hydrochloric acid solution was instilled into the stomach. Within a period of one to nine minutes, the former typical ulcer distress reappeared in all of its former severity. While this experiment does not necessarily prove that the ulcer pain and distress is due directly to the free hydrochloric acid, since the motility of the stomach was not simultaneously

FIG. 6.—X-ray film showing definite decrease in gastrojejunal ulcer crater 25 days after transthoracic vagotomy.

FIG. 5.—X-ray film showing a large gastrojejunal ulcer crater following antral exclusion and subtotal gastric resection.

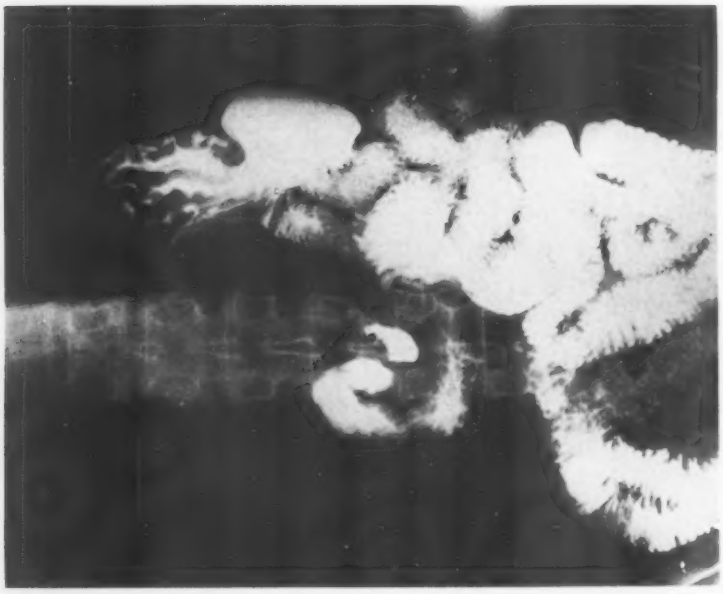

FIG. 8.—X-ray film showing absence of gastrojejunal ulcer crater 21 months after transthoracic vagotomy and also retrograde filling of the duodenum and antrum of the stomach.

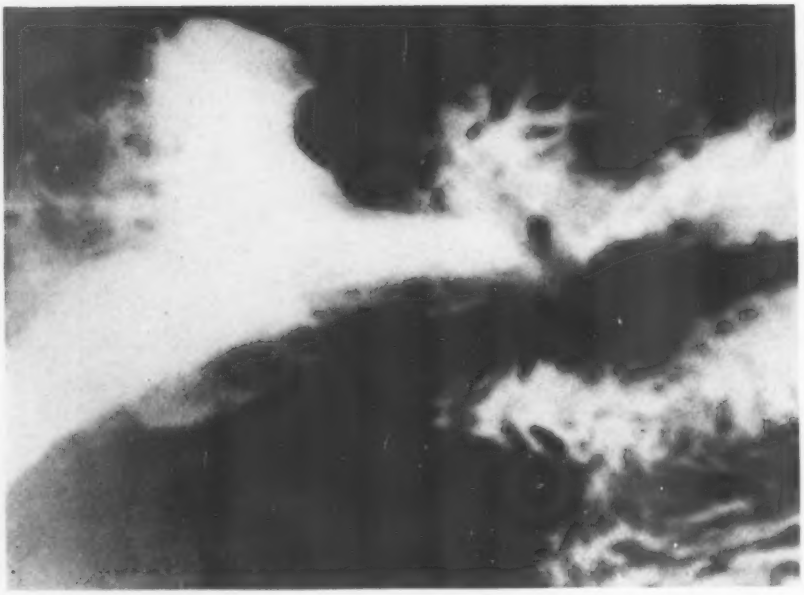

FIG. 7.—X-ray film showing complete disappearance of gastrojejunal ulcer crater 47 days after transthoracic vagotomy.

studied, it does indicate that the stomach has not been rendered anesthetic by the operation.

The beneficial effect of vagus section in the healing of peptic ulcer is especially well illustrated in 14 of our patients in whom this operation was done for recurrent gastrojejunal ulcer following either gastroenterostomy or subtotal gastric resection. A detailed report of these findings has been published elsewhere. We should like to refer here to an additional patient with a gastrojejunal ulcer who presents some features that are of special interest. The patient, a male, age 36, was first seen on August 29, 1938. For the previous two months, he had been complaining of typical ulcer distress, and x-ray examination revealed a duodenal ulcer with a crater. Symptoms were controlled for a time on medical management but recurred in severe form in 1943, and surgery was requested. At operation, a large, chronic, duodenal ulcer penetrating into the pancreas was found. Because of the extensive involvement, a Finsterer-Devine type of exclusion operation was performed with subtotal gastric resection. Six months after the operation, a recurrence of symptoms developed, and a gastrojejunal ulcer was demonstrated at x-ray. X-ray therapy to the stomach was then given with relief of symptoms, and there was apparent disappearance of the ulcer crater. The symptoms recurred in six months, and the pain became more severe. X-ray examination again revealed an ulcer crater (Fig. 5). On March 23, 1945, a transthoracic supradiaphragmatic section of the vagus nerves was performed. Recovery was uneventful, and the patient was entirely relieved of ulcer distress. X-ray examination on April 16, 1945, revealed definite decrease in the size of the ulcer crater (Fig. 6), and on May 9, 1945, complete disappearance of the crater (Fig. 7). He remained well, resumed his former occupation, and was able to eat an entirely unrestricted diet without any type of medication. Fluoroscopic examination of the stomach was made in December, 1946, and the findings proved to be most interesting (Fig. 8). The film shows no trace of an ulcer crater, and the stomach and jejunum are well outlined with barium. Of great interest is the demonstration of a retrograde passage of the barium through the duodenum, the pylorus, and into the antrum of the stomach, which was left behind at the time of the operation. The increased incidence of gastrojejunal ulcer following gastric resection in which the antral mucosa is left unremoved has been well recognized. The explanation offered for the high incidence of jejunal ulcers in these cases is that this mucosa makes possible the continued excessive secretion of gastric juice, presumably through the elaboration of gastrin as called for in the hypothesis of Edkins. The work of Edkins, however, indicated that gastrin is liberated from the antral mucosa only on contact with food. Here is visual evidence that a retrograde passage of the gastric content through the duodenum, through the pylorus, and into the antrum, can occur, which fulfill the requirements for the liberation of gastrin and its stimulating action on the gastric glands. It is significant, therefore, that in this patient a large jejunal ulcer healed following complete

vagus section, even though that part of the humoral mechanism for gastric secretion controlled by the antral mucosa was still present.

SUMMARY AND CONCLUSIONS

During the period from January 18, 1943, to March 1, 1947, division or resection of the vagus nerves to the stomach as a method of treatment has been employed in the University of Chicago Clinics in 212 patients with various types of peptic ulcer. One patient died of aspiration bronchopneumonia, and there have been no deaths in the last 150 vagotomies performed. Adverse reflex effects that might be ascribed to stimulation of the vagus nerves have not been seen. The clinical results of the operation have been excellent and have led us to the impression that a benign peptic ulcer may be regularly expected to heal if all the vagus fibers to the stomach are divided. This is best accomplished by exposure of these nerves along the lower esophagus by either a transabdominal or a transpleural approach. The transabdominal operation has the significant advantage that it makes possible inspection and palpation of the lesion and the performance of a gastroenterostomy should cicatricial obstruction at the pylorus be present. Gastric vagotomy abolishes the nervous phase of gastrin secretion and decreases very markedly the total amount of gastric juice produced. These effects appear to be permanent. Evidence of regeneration of the secretory fibers in the vagus nerves has not been observed even in the patients operated upon four years ago. These findings suggest that regeneration of the divided vagus fibers will not prove to be a troublesome feature of this type of operation. Complications and undesirable sequelae that have been encountered are intercostal pain or neuralgia, pleural effusion, pulmonary atelectasis, delayed emptying of the stomach, and diarrhea. For the most part, these complications have been mild and self-limited. Careful attention to postoperative care reduces the incidence and severity of most of them. Persistence of ulcer symptoms has been observed in five patients, and in these, physiologic tests have indicated that not all the vagus fibers were divided. In two of these patients, a second operation was performed, and a residual vagus fiber was discovered and divided.

These findings suggest that to be effective in abolishing the nervous phase of gastric secretion and causing the healing of benign peptic ulcers, removal of the vagus innervation of the stomach must be complete. It is probable that the poor results secured by the early workers in this field are due to the fact that attempts were made to section the vagus nerves in operations directed at the stomach instead of the esophagus and thus were in all probability incomplete. The necessity of repeated physiologic tests to determine residual vagal innervation of the gastric glands is clear and should be emphasized.

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DISCUSSION.—DR. KEITH S. GRIMSON, Durham, N. C.: I wish to thank Dr. Walters and Dr. Firor for arranging the privilege of the floor, and to congratulate Dr. Dragstedt, Dr. Moore, Dr. Walters and Dr. Griswold on their excellent studies. There can be little doubt now that Dr. Dragstedt's reintroduction of vagotomy has profoundly influenced surgical management of ulcer. This is best evidenced by the 500 cases reported this afternoon including our 77, and by the continuing use of vagotomy by each author even though few cases have been followed for more than two years.

Since vagotomy is in a stage of evaluation, I should like to express agreement with certain observations presented. First, with very few exceptions healing or quiescence of ulcer occurred. Failure in two of our patients necessitated secondary subtotal gastric resection. Second, changes of acidity and motility have been variable, but usually acidity of fasting gastric content and response to histamine or insulin hypoglycemia have been reduced and emptying of the stomach delayed. There has been some evidence that some but not all of these variations may be caused by incomplete vagotomy. Excellent clinical results have occurred, however, in patients with a positive insulin test. Since changes of secretion and motility usually persisted in patients studied for two or three years, regeneration is not likely to be a limiting factor.

Unfortunately we have had more trouble with complications than most. Greatest has been the necessity for performing seven secondary gastroenterostomies, or one among each seven patients who did not already have enterostomy. Gastric retention six hours after taking barium has been greater than 30 per cent in all patients without gastroenterostomy and often 50 to 90 per cent. It is our belief that physiologic obstruction of the outlet of the stomach occurred and was a more important cause of retention than scarring from ulcer. Resting intragastric pressure or tone, according to our observations, increased slightly after vagotomy. Gastric retention was relieved by gastroenterostomy or occasionally by urecholine or doryl. Diarrhea occurred in some patients. Although complications have been serious at times, most patients are relieved of symptoms of ulcer, satisfied and able to work. Only a few have not gained weight. At the present time we are employing subdiaphragmatic vagotomy with pyloroplasty, exclusion or gastrojejunostomy for duodenal ulcer, and reserving transthoracic vagotomy alone for stomach ulcer.

DR. RALPH COLP, New York: I have had the privilege of previously reading Dr. Walters' interesting communication. From our limited experience I agree that the results following the severance of the vagus nerves to the stomach in the treatment of peptic ulcer are "inconsistent, variable and in most cases unpredictable." I shall not discuss the effects of vagotomy on acid secretion. I shall confine my comments mainly to the postoperative motor difficulties which apparently bear little relationship to the completeness or incompleteness of the division of the vagi as revealed by the insulin test.

I should like to present a series of 20 cases of chronic duodenal ulcer without obstruction. At that time, we performed supradiaphragmatic vagotomy. All cases but one follow-

ing operation were immediately relieved of pain. This patient was explored two months later. In spite of a negative insulin response, an active posterior wall duodenal ulcer was found and a subtotal gastrectomy was performed. Eight patients have remained well from three to eight months. Eleven of these patients following supradiaphragmatic vagotomy complained of epigastric fullness, gastric oppression, foul eructations and vomiting due to gastric dilatation with retention. In seven, symptoms eventually disappeared in from one to seven months, but four failed to respond to medical treatment in spite of repeated hospitalizations. These patients were so miserable that they requested surgical therapy in from six to eight months following supradiaphragmatic vagotomy. In these cases (Table II) surgical exploration revealed that the ulcer had healed, that the pylorus was patent in all, but in three the stomach was markedly dilated. In the latter instance a subtotal gastrectomy was performed. The immediate postoperative course was uneventful and at no time since have there been any symptoms which could be ascribed to gastric atony. In one patient in whom exploration disclosed a slightly dilated stomach, a dilated duodenum and colon, nothing was done. He still remains miserable.

Twenty cases is admittedly a small series, but the fact that five of these patients required another surgical exploration, one for persistent pain and four for intractable motor disturbances, has convinced us that severance of the vagus nerves as a sole procedure should not be offered to patients with chronic duodenal ulcer without obstruction as a reliable therapeutic measure. We therefore have discontinued it for the present.

In our first 33 cases the vagi were divided transthoracically (Table I). In our last 44 patients we have used the infra-diaphragmatic approach (Table III). The exposure and division of the vagi beneath the diaphragm is perfectly satisfactory. This method has the distinct advantage in that it permits a thorough abdominal exploration and offers an opportunity for studying the gross pathology of the local lesion. We have performed an infradiaphragmatic vagotomy with complementary gastroenterostomy in 15 patients whom we did not consider to be suitable risks for subtotal gastrectomy. Aside from one aged patient who died from a peritonitis, incident to secondary jejunostomy for alimentation due to gastric atony, the remainder have not suffered from any prolonged postoperative disturbances. From past experiences it is known that symptoms of a duodenal ulcer *per se* are invariably relieved by gastroenterostomy, and that the ulcer heals. The unfortunate disadvantage of this simple operation is the high incidence of gastrojejunal ulceration. Perhaps careful follow-up studies over the next five years will demonstrate the efficacy of combining gastroenterostomy with infradiaphragmatic vagotomy in either reducing or eliminating the incidence of gastrojejunal ulceration. Until then we shall continue to perform subtotal gastrectomy as the operation of choice for duodenal ulcer. We shall combine it with infradiaphragmatic vagotomy, especially in those patients whose preoperative free acid studies are high, and those in whom bleeding without pain was the outstanding symptom, two categories in which recurrent gastrojejunal ulceration occasionally occurs. We have combined the procedures in 26 cases without undue risk to patients. The postoperative course has been uneventful, and up to the present there have been no difficulties ascribable to delayed gastric emptying. With the elimination of both the vagal and hormonal phases of gastric secretion, an anacidity is usually produced and, under such conditions, recurrent jejunal ulcer and hemorrhage should not occur. It is also possible that the incidence of the dumping syndrome, so distressing to some patients, may be lessened. However, final comment must await adequate follow-up.

The most striking benefits following severance of the vagus nerves are seen in patients suffering from gastrojejunal ulceration. In four cases of gastrojejunal ulcer following gastroenterostomy and in 11 cases following subtotal gastrectomy, excellent immediate results following vagotomy have been observed. In these patients the excruciating abdominal pain was immediately relieved, the free gastric acidity was either materially reduced in quantity or an anacidity was produced, and the jejunal ulcers which were previously demonstrated by x-ray with barium rapidly disappeared. The postoperative course was not marked by any gastric disturbances. Up to the present, 12 cases have remained well and

in three patients there have been recurrences, but in these cases the insulin test revealed that the vagus nerves were incompletely divided.

The problem of gastric ulcer is another important consideration. I regret that I did a supradiaphragmatic vagotomy in one case, although the ulcer disappeared and the patient has remained well. The surgeon is never absolutely sure that an ulcer of the stomach is not malignant. The only safe method is the radical removal of the lesion for pathologic examination by subtotal gastrectomy. The clinical results of that procedure have been uniformly regarded as excellent over a twenty year period, and there is no reason to discard subtotal gastrectomy if there is even the remotest possibility that a vagotomy may be performed for an unsuspected malignancy.

TABLE I

SUMMARY

33 Cases Treated by Supradiaphragmatic Vagotomy

No. of Cases	Diagnosis	Predominant Symptom	Results
20	Duodenal ulcer	3—Bleeding—1½ to 7 yrs. 17—*Intractable pain*—1½ to 25 yrs.	8—Well—6 to 12 mos. 7—Motility disturbances—lasting 1 to 10 mos. 4—Motility disturbances—6 to 8 mos. Requiring surgical therapy 1—Persistent ulcer pain—2 mos. Requiring surgical therapy
1	Gastric ulcer	Pain—4 yrs.	Well—12 mos. (Motility disturbances, 5 mos.)
10	Gastrojejunal ulcer following subtotal gastrectomy for duodenal ulcer	1—*Bleeding*—1½ yrs. 9—*Pain*—4 mos. to 6 yrs.	4—Well—6 to 18 mos. 2—Improved—11 to 14 mos. *2—Recurrences of bleeding—13 mos. postoperative 1—Recurrence of pain—10 mos. postoperative 1—Death—14 days after operation (hemorrhage into left adrenal gland)
2	Gastrojejunal ulcer following gastroenterostomy for duodenal ulcer	2—*Bleeding*—6 to 9 yrs.	1—Well—17 mos. 1—Well—7 mos. (Motility disturbances 2 mos.)

* One case previously reported in Tr. Am. Surg. Assn., Vol. LIX, 1941, p. 334.

DR. FRANK H. LAHEY, Boston: These papers represent a very fair presentation of what is going on with vagotomy. I want to present one thing unfavorable to subtotal gastrectomy, and the relation of vagotomy to it, based upon our experience with it. The members of our gastroenterologic department have been studying patients who have had bleeding after subtotal gastrectomy done for a bleeding duodenal ulcer. Of 100 patients having duodenal ulcer who have had subtotal gastrectomy with hemorrhage as the indication for surgery, and in whom the subtotal gastrectomy was at a very high level and the bleeding ulcer removed in every case, 28 have bled postoperatively. Although only five of these patients were proved to have jejunal ulcer, it seems reasonable that the remainder must have had at least some mucosal ulceration to have produced the bleeding. Many of these patients have not bled again and are perfectly well, but this is a disturbing percentage of bleeding cases after subtotal gastrectomy for bleeding duodenal ulcer.

When we have a group of 28 patients with postoperative bleeding out of 100 with partial gastrectomy, we believe that anything that can be added to make the operation more aggressive should be done. We therefore believe that in all subtotal gastrectomies done upon patients with bleeding duodenal ulcers, infradiaphragmatic vagotomy is a valuable measure to be employed in addition to the subtotal gastrectomy, and we recommend and have employed this additional procedure.

Regarding our use of vagotomy, we would not employ this procedure, as has been

done, in any patient with a gastric ulcer because of the dangers, which I have already stated in a previous discussion, of overlooking malignancy. We particularly employ vagotomy, preferably transthoracic vagotomy, for jejunal ulcers which have occurred after subtotal gastrectomy. We would employ vagotomy for duodenal ulcers at or below the entrance of the common duct into the duodenum, and for those occasional low duodenal

TABLE II

RECURRENCES FOLLOWING SUPRADIAPHRAGMATIC VAGOTOMY

Case	Preoperative Diagnosis and Symptoms	Date of Vagotomy	Postoperative Symptoms	Date of Abdominal Exploration		Operative Procedure
J.R. 547866	Duodenal ulcer Pain—4 yrs.	5/ 2/46	Vomiting Foul eructations Pain	12/12/46 7 mos.	*Ulcer*—Healed *Pylorus*—Patent *Stomach*—Slightly dilated *Colon and duodenum*—Dilated	Exploration only
R.H. 548657	Duodenal ulcer Pain—6 yrs.	5/16/46	Vomiting Foul eructations	1/ 9/46 7 mos.	*Ulcer*—Healed *Pylorus*—Patent *Stomach*—Twice normal size	Subtotal Gastrectomy
A.J. 548450	Duodenal ulcer Pain and vomiting 25 yrs.	5/16/46	Vomiting Foul eructations	10/28/46 5 mos.	*Ulcer*—Healed *Pylorus*—Patent *Stomach*—Dilated	Subtotal Gastrectomy
A.A. 549604	Duodenal ulcer Pain 1½ yrs.	6/ 3/46	Vomiting Foul eructations Pain	12/ 2/46 6 mos.	*Ulcer*—Healed *Pylorus*—Patent *Stomach*—Dilated and flabby. Scar of old gastric ulcer	Subtotal Gastrectomy
W.K. 547393	Duodenal ulcer Pain—1½ yrs.	5/13/46	Vomiting Pain	7/ 8/46 2 mos.	*Ulcer*—Active *Pylorus*—Moderate stenosis *Stomach*—Normal	Subtotal Gastrectomy

TABLE III

SUMMARY

44 Cases Treated by Infradiaphragmatic Vagotomy

No. of Cases	Accompanying Procedure	Diagnosis	Results
3	Vagotomy only	Gastrojejunal ulcer 2—After gastroenterostomy 1—After subtotal gastrectomy	Recent
15	Gastroenterostomy	Duodenal ulcer	1 Died from secondary jejunostomy (peritonitis) 1 Well—14 mos. 13 Recent
26	Subtotal gastrectomy (1 prepyloric exclusion)	24 Duodenal ulcer 2 Gastrojejunal ulcer after gastroenterostomy	6—Well—5 to 17 mos. 1 Improved—11 mos. 19 Recent

ulcers so adherent to the common duct that we do not believe they could be resected safely. We know from our own experience that there are rare duodenal ulcers occurring in the duodenum below or at the level of the entrance of the duct in which, if resection were done, transplantation of the common and pancreatic ducts, as we have occasionally done, would be necessary. We would in addition like to select a series of uncomplicated duodenal ulcers in which we could do a transthoracic vagotomy without the need of other complicating

operations such as gastroenterostomy, with the hope that we could eventually interpret for ourselves the value of this procedure in this group of patients in whom but a single procedure (vagotomy) has been applied.

DR. PAUL H. THORLAKSON, Winnipeg: I belong to the group of surgeons who have observed this new procedure with considerable hope but with some skepticism. May I summarize, without comment, the experience at the Winnipeg Clinic in 39 cases of gastric, duodenal and marginal ulcers subjected to vagotomy. My associates in the department of surgery, Dr. M. B. Perrin and Dr. K. R. Trueman, working in collaboration with Dr. J. W. Macleod of the department of medicine, are chiefly responsible for the selection of cases and for the pre- and postoperative studies as well as the surgical procedure in this series. The series began in May, 1946, and includes those treated up to February of this year.

Our series consists of 39 cases with no mortality. Thirty-three underwent intrathoracic and six subdiaphragmatic vagotomy. The ages varied from 21 to 59 years. There were five women and 34 men in the series. Thirty-four of the patients had duodenal ulcer, two had gastric ulcers and two had marginal or stoma ulcers. Seven of these patients had had previous gastroenterostomies.

The immediate results have for the most part been unusually satisfactory. Certain early difficulties have been reduced as our experience has increased.

There has been in all cases after the operation relief of ulcer pain. Obviously it is too early to know how permanent this may be. The great majority have felt well and have gained weight. There has been a very appreciable improvement in their outlook on life. The ulcer craters have healed in a relatively short time as demonstrated by x-ray studies. Gastric acidity has been reduced and in some there is an achlorhydria. However, in some there has been a response to the insulin hypoglycemia test, indicating the possibility of surviving intact vagus nerve fibers.

A number of postoperative conditions have been encountered. In 21 cases fluid was present in the chest, as evidenced clinically or by x-ray film. In only seven was it necessary to require aspiration. Several of these latter had a troublesome cough and severe pain in the chest, which were considerably relieved by aspiration of the fluid. Dysphagia was a complaint in five instances; the difficulty was for the most part temporary, although esophagoscopy was resorted to in one patient to provide relief as well as to investigate the possibility of damage. Diarrhea has occurred in four cases. It has not been serious and tends rather to be intermittent. Most cases have shown some gastric retention after surgery and in three it has been marked. A most stubborn case was advised to have gastroenterostomy for relief, but the patient refused. A recent advice from him indicates that he has felt well and gained weight.

One patient, having a large gastric ulcer of long duration, showing an atonic stomach and prolonged emptying time, still has her ulcer, decreased in size, but present.

Two cases with duodenal ulcer have their ulcers at the present time; one is a recurrence and one has not healed in six months. Both these cases showed acid response to insulin injection postoperatively. These may be cases of incompletely sectioned vagus nerves; it is possible some fibers enter the wall of the esophagus and cannot be seen or felt at the time of operation.

At the present time it is our feeling that the delayed emptying of the vagotomized stomach does not constitute such a problem that gastroenterostomy should be performed routinely. By such a combination of procedures one cannot correctly evaluate a method of therapy which by itself appears to possess much merit.

DR. WILLIAM DEW. ANDRUS, New York: I should like to introduce into this discussion a report of physiologic studies which, while made on a single patient, have shown certain interesting effects of vagotomy.

The patient was a man about 50 years of age who entered the hospital with almost complete obstruction of the esophagus due to carcinoma. The size and extent of the growth above the arch of the aorta made it appear from the x-ray that the growth was inoperable, or if operable that a complete resection of the thoracic esophagus would be required. A gastrostomy of the Glassman type was therefore performed for feeding purposes and in order to permit more direct observations on gastric function, Dr. Stewart Wolf then collaborated with us in making extensive studies on this patient, similar to those made with Dr. Harold Wolff on "Tom", a man with a permanent gastrocutaneous fistula. While because of anacidity it was not possible to study the secretion of acid in this patient, a variety of other studies were carried out, among them investigations of the effects of emotion on the gastric mucosa.

It happened that this patient felt very resentful about the way his case has been handled by a certain doctor before the diagnosis was made, and when questioned about his treatment before entering the hospital his face would become flushed and he would swear and show other evidences of extreme resentment and anger. During such an episode the gastric mucosa observed through the gastrostomy would become very engorged and red, showing changes identical with those seen by Wolff and Wolf in "Tom" under similar emotional stress. These studies were carried out on several occasions before exploratory thoracotomy was performed. At the time of this operation the growth was found to involve the aortic arch and the surrounding structures to such an extent as to be inoperable. A supradiaphragmatic section of the vagus nerves was, however, carried out and after about two weeks had elapsed the pre-operative studies of gastric physiology were repeated. The most striking finding was the fact that episodes of resentment now, while they were associated with flushing and external signs, no longer produced any changes in the gastric mucosa.

These studies suggest that after vagotomy the changes in the gastric mucosa associated with certain emotions such as the turgescence which has been shown to lead to increased susceptibility to superficial erosion or injury, may be eliminated.

Dr. Edwin M. Miller, Chicago: One would be bold to attempt to add very much to this very instructive symposium, but one statement can be made, I am sure, without fear of contradiction, i.e., that this work of Dr. Dragstedt and his associates has brought before the public a topic that has provoked more discussion and more argument than any in the entire field of surgery in recent years. Not only does this apply to meetings where doctors are gathered together, but to gatherings of lay people as well, especially where doctors' wives are present, or patients suffering from peptic ulcer. One can also, in the mind's eye, see innumerable examples over this country of small family gatherings where one member has had an ulcer, and as a result all of them have become more or less familiar, either through the daily newspaper, literary digests, or medical magazines, with this new treatment for the disease. This widespread publicity will doubtless in the long run be a good thing, yet temporarily it may be detrimental to progress in this field. There will be many doctors who will be carried away by the general enthusiasm, will be over-zealous in performing these vagus nerve operations, with unsufficient indications, without adequate preoperative study, without technical ability, and who have not the laboratory facilities for making careful postoperative follow-up studies. As a result, inaccurate observations may be published, and the true worth of vagus nerve sections in the treatment of chronic peptic ulcer may not be determined for a long time.

We hesitate at this time to make any definite statements about results in our own cases; first, because the series (15 personal cases and 25 others) is very small; second, because the elapsed time since our first operation has been too short. However, we can with certainty say that we are thus far very favorably impressed with the progress of our patients. We have preferred the transthoracic approach, because our anatomic studies have shown us that a more accurate dissection can be made through the chest, and therefore the chance of leaving behind undivided vagus nerve branches is minimized. Yet

we acknowledge the necessity of the abdominal route when the need for a gastroenterostomy is present.

Our postoperative complications have been few in number, minor in degree, and temporary in duration. Among them may be listed cardiospasm, pylorospasm, delayed emptying of the stomach, pain in the chest, mild paralytic ileus, and diarrhea. A more definite statement can be made after much more time has elapsed.

DR. R. KENNEDY GILCHRIST, Chicago: I have heard this discussion three times, and there is one question I would like to have answered. It seems that we have intestinal upsets after surgery. Before surgery, there is high acidity, and after surgery, no acid is present. Also, there is very much delayed emptying time of the stomach. With the absence of acid, this establishes a perfect culture medium. It seem that one of the most common complications is diarrhea. I would like to know how much work has been done on the question as to whether there is a change in the flora of the stomach, or whether some peculiar flora is present which, when the contents of the stomach are emptied into the intestine, causes the diarrhea.

DR. HAROLD M. WOOKEY, Toronto: I have listened with a good deal of interest to the symposium on the effects of vagotomy on the function of the stomach and to its application in the treatment of peptic ulcer. It has been suggested that the full beneficial effects of this procedure would not occur unless all the vagus fibers were included. I have found that the esophagus and vagi are more easily reached by a rightsided approach through the thorax. The vagi may then be divided at a higher level and in this way one would be more certain that all fibers proceeding to the stomach are included. In my opinion, this is a simpler operation and less disturbing to the patient.

DR. OWEN H. WANGENSTEEN, Minneapolis: As physiologist and surgeon Dr. Dragstedt has made contributions of the greatest importance to our understanding of gastric physiology. I am certain that surgeons and physiologists generally are awaiting with keen interest the outcome of this new venture of Dr. Dragstedt in attacking the problem of ulcer by the performance of complete vagus section. In our clinic, there is an intense interest in the ulcer problem, both in the hospital and in the laboratory. With reference to the question of vagotomy, however, we have felt this is a problem which should be threshed out in a few areas. Yet in my community, a number of surgeons in the Twin Cities who had never explored the possibilities of resection are performing vagotomies in large numbers. In January, Dr. Walters and his associates from Rochester presented their material on vagotomy. His results suggest definitely that vagotomy does not consistently afford patients with ulcer that degree of protection which one would like to find in an operative procedure. As a matter of fact, following Dr. Walters' talk on vagotomy for ulcer in St. Paul, it was to be noted that all the lobby telephones were busy. Internists and surgeons alike probably were already cancelling vagotomies that had been scheduled. In any case, in my area, the enthusiasm for vagotomy has been dampened perceptibly by the report of Dr. Walters and his colleagues.

It would be very helpful indeed if an experiment could be devised by which the protection afforded by vagotomy against the ulcer diathesis could be tested critically. Pavlov showed that vagotomy ablated the cephalic or psychic phase of gastric secretion. Moreover, Dr. Dragstedt has shown that vagotomy has a profound depressing influence on gastric secretion in man. Vagotomy, however, does not impede humoral stimuli of gastric secretion. And in dogs, whereas there is an early depression of gastric secretion following vagus section, with the elapse of time there appears to be a fairly complete recovery viewed from the over-all response to a meat meal.*

* Discussion of Dr. L. R. Dragstedt's paper "Section of the Vagus Nerve in Treatment of Gastrojejunal Ulcer." Minn. Medicine, 21: 604, 1946.

Vagotomy fails to protect against the histamine-provoked ulcer in the dog (Ivan D. Baronofsky, Stanley Friesen, Enrique Sanchez-Palomera, Frank Cole, and Owen H. Wangensteen: 62:114, 1946). Obviously, there is no real antithesis between vagotomy and histamine, for histamine will stimulate the parietal cells after vagotomy. Hence, Dr. Dragstedt justifiably may object to testing the protection afforded by vagotomy against the histamine-provoked ulcer. However, the very circumstance that vagotomized patients will not be protected against humoral influences such as food, caffeine and alcohol, which stimulate the parietal cells to secrete hydrochloric acid, suggests that vagotomy may prove an inadequate protection against the ulcer diathesis of man. Even in dogs, vagotomy will retard the histamine-provoked ulcer but it will not preclude its occurrence. My associates and I are trying to determine in the laboratory whether vagotomy will protect against some of the abetting causes of ulcer. It will be particularly interesting to try to determine whether vagotomy will abolish the ulcerogenic effects of tension-states. My associate, Dr. Walter Lillehei, is accumulating some interesting data on the effects of stimulating the extrinsic nerves of the stomach as well as on the effects of removal of its extrinsic nerve supply. Sympathectomy definitely abets the ulcer diathesis in dogs and we might reasonably assume that some patients who have undergone sympathectomy for hypertension may develop ulcer. Vagotomy, on the contrary, does exhibit a retarding effect on the development of ulcer. The extent of this delaying or retarding influence remains to be determined.

When a patient with an ulcer submits to operation for its correction, he may rightfully expect protection from ulcer recurrence. That, however, has been the great weakness of operations devised to rid a patient of the ulcer diathesis. We surgeons have been too empirical in our approach to this problem. Dr. Dragstedt's medical associate, Dr. W. L. Palmer, is author of the statement that 40 per cent of patients for whom gastrojejunostomy was performed for duodenal ulcer at the University of Chicago Clinics developed gastrojejunal ulcer.* That gastrojejunostomy sensitizes a dog to the occurrence of gastrojejunal ulcer is well known.** This circumstance is even more evident in dogs receiving histamine-in-beeswax after gastrojejunostomy; ulcer occurs much more readily than it does in the dog that has not undergone gastrojejunostomy.

The wisdom of adding gastrojejunostomy to vagotomy to thwart the ulcer diathesis in man is therefore a debatable matter.

Dr. R. Arnold Griswold, Louisville, Ky. (closing): My personal experience with vagotomy is limited to 34 cases. I will simply say that the results have been satisfactory to us and to the patients, with about the same ratio of good results and side effects as presented by the other speakers. In addition to the chemical work Dr. Schoen has done, we have been interested in the psychiatric side of the ulcer problem. Dr. Arthur Benton of the University of Louisville Mental Hygiene Clinic, has been doing psychologic tests including the Rorschach test and the Minnesota multiphasic personality inventory on these patients before and after operation. All patients tested preoperatively showed more or less severe degrees of psychologic disturbance. The majority showed emotional constriction, a pattern usually associated with severe psychoneurosis. Others showed the type of performance often found in chronically maladjusted, aggressive individuals who show evidence of hostile and (using the term in a broad sense) paranoid attitudes. Since vagotomy may be considered as separating the soma from the psyche, we have been interested in repeating these tests postoperatively. So far, in the small number of individuals tested, postoperative tests have shown no psychologic change due to relief of the ulcer symptoms. They are still the same emotionally disturbed individuals as they were before operation. Tests will be continued at a later date following operation, since the average postoperative test so far has been about two months postoperative.

* Journal-Lancet, **62**: 415, 1942.

** Montgomery, A. H.: Gastrojejunal ulcer; an experimental study, Arch. Surg., **6**: 136, 1923.

Concerning the question of operative approach, we have favored the thoracic exposure because of the greater ease, facility and certainty of dividing all vagal fibers, as well as the lessened morbidity following this approach. Of course, in those cases in which a drainage operation is necessary, or in which it is felt necessary to visually and manually examine the pathology, the abdominal approach has been used. We have used the abdominal approach in about 25 per cent of our cases. Routinely, I do not think it makes much difference. It is a minor problem, such as whether you remove a gallbladder from the fundus down or the cystic duct up. The surgeon who is more familiar with abdominal surgery than with thoracic surgery will probably always prefer the abdominal approach. I do not think it is a matter of much importance.

DR. FRANCIS D. MOORE, Boston (closing): I would like to thank the essayists and discussors for a most instructive afternoon. One point should be emphasized that I did not stress before, namely, that one year after vagus resection the fasting acidity and motility of the stomach have readjusted themselves to denervation and returned to essentially normal values. I am not referring to overnight suction experiments such as Dr. Dragstedt has studied, but rather to serial determination of the titratable acidity and pH of the secretion. The "psychic phase" is doubtless still abolished and the insulin curves remain "flat." However, we should not lose sight of the fact that a year after vagus division titratable free acidity in the stomach is often 20 and 50 units and a pH between 1 and 2. We should therefore not refer to vagus division as an operation which lowers gastric acidity. It produces a temporary change in fasting acidity, and doubtless a permanent change in acidity produced in response to cortical stimuli.

As to the fibers which have been found in the wall of the esophagus, I am quite puzzled as to the proper interpretation of these data. We dissected a good many cadavers before we carried out our first human operation, and in all of these we found fibers of the vagi in the esophageal wall. These fibers, which are occasionally fairly good size, ran down and ended for the most part in or just below the cardiac orifice. We interpreted them as motor fibers to the muscular wall at the junction of esophagus and stomach. I would not feel convinced that sectioning one of these small fibers had accomplished much change in the physiologic conduct of the rest of the organ.

As for doing this operation with subtotal gastrectomy, I have shuddered when this has been mentioned as a routine procedure. It did not seem justified to subject a large group of patients to the side effects of vagus division when they were already having an operation carried out which has its own imposing list of by-products. However, there may remain a special group of cases such as Dr. Lahey mentioned in which the combination is justifiable.

We operate through the chest purely for anatomic reasons, feeling that we do a better job.

Although vagus resection is in a very difficult phase to evaluate I think that it is going to work itself into the overall picture in a fashion analagous to splanchnicectomy for hypertension. In both situations we have varying combinations of local, humoral, neurogenic, and environmental factors responsible. The nerve-dividing operation controls only those patients in whom nerve-mediated factors are of outstanding significance. I would never expect 100 per cent good results from this operation if applied to an unselected ulcer population. The reason for this is that in a large group of ulcer patients these various etiologic mechanisms are at work in varying combinations. I think the final solution of our problem is going to come when, by careful research, we learn how to select those patients in whom the nerve-mediated factors outweigh in importance the other ulcer-producing mechanisms.

DR. WALTMAN WALTERS, Rochester, Minn. (closing): In answer to Dr. Gilchrist's question, is it not likely that one cause for the diarrhea is jejunitis, which is found in some who have had persisting symptoms. In nine dogs in whom the Mann-Williamson

ulcer was produced, Saltzstein and Sandwiss found severe jejunitis present in six. These dogs had diarrhea. Bacterial contamination of food remnants remaining in the stomach as a result of gastric stasis from atonicity is another possibility, as Dr. Gilchrist has mentioned.

Dr. Lester R. Dragstedt, Chicago (closing): I should like first to refer to Dr. Wangensteen's comment. We are greatly indebted to him and to his associates for one of the most significant experiments on the pathogenesis of peptic ulcer. He demonstrated that if an excessive, continuous secretion of gastric juice is produced and maintained in experimental animals, peptic ulcers regularly develop. This excessive gastric secretion was produced by implanting pellets of histamine and beeswax into the subcutaneous tissues. The gradual absorption of histamine from these pellets provided a long continued chemical stimulation of the gastric glands in the intervals between meals. I am not surprised at Dr. Wangensteen's statement that these histamine ulcers can be regularly produced in animals even after division of the vagus nerves. So far as we know, histamine acts chiefly locally on the neuroglandular apparatus in the stomach and not on the brain. Section of the vagus nerves, therefore, should not interfere with the secretory effect of the absorbed histamine. I should like to emphasize again that in patients with peptic ulcer, the excessive, continuous secretion of gastric juice is neurogenic in origin and is abolished by division of the vagus nerves to the stomach. The excessive, continuous secretion of gastric juice produced by the implantation of pellets of histamine and beeswax into the subcutaneous tissue, on the other hand, is chemical in origin and should not be abolished by sectioning the vagus nerves to the stomach. The situation in the two cases is, therefore, not comparable.

Early in our work with gastric vagotomy in the treatment of peptic ulcer, we were impressed with the profound decrease in tonus and motility of the stomach which follows this operation. It is important, however, to realize that whereas the motility is reduced, it is not abolished, and that after a time, a readjustment in the peripheral automatic motor mechanism of the stomach takes place so that the gastric movements return toward the normal state. In the interval, however, the stomach is very susceptible to the dilating effect of swallowed air and accumulated secretion. Overdistention of the stomach at this time markedly delays the resumption of normal motility through the agency of Auerbach's plexus. It is our usual practice to decompress the stomach by means of the Wangensteen apparatus for five days following the vagus section, then allow small amounts of water, and subsequently aspirate the stomach to determine if retention has occurred. Only when liquids empty readily do we allow solid food. The patients are carefully instructed not to overload the stomach for the first few months following the operation. The dietary restriction is thus quantitative rather than qualitative in nature.

I was very much interested in Dr. Moore's statement that within a year following section of the vagus nerves to the stomach, the secretion of gastric juice and motility return to the preoperative level. In our experience, section of the vagus nerves has abolished permanently the nervous phase of gastric secretion. I think this is most important. Up to the present time, we have secured no evidence of regeneration of the secretory fibers in the vagus nerve to the stomach as determined by physiologic tests. The usual failure of the recurrent laryngeal nerve to regenerate following damage in thyroid surgery is of interest in this connection. While the period of clinical observation is still too short for us to know whether or not recurrence of these ulcers that have healed following vagus section will take place, the data from the experimental laboratory permit us to be quite optimistic. I do not believe that these ulcers will recur unless the vagus nerves regenerate and the excessive, continuous secretion of gastric juice of nervous origin is resumed. Since regeneration of these nerves has not been seen even in the patients operated upon four years ago, it seems unlikely, on the basis of what we have learned about regeneration of nerves elsewhere, that this will take place.

ABDOMINAL VISCERAL SENSATION IN MAN*

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THE RECOGNITION of the existence of visceral pain has been comparatively recent. Before and for some years after Langley's[1] (1903) review of the functions of the autonomic nervous system it was believed that such afferent fibers as were known to accompany autonomic nerves served only in reflex mechanisms to autonomic tissues and were "incapable of directly giving rise to sensation." Ross[2] in 1887 had shown that tension in a hollow viscus produced pain that was perceived in a corresponding cutaneous dermatome on the abdominal wall. But Lennander[3] (1902) as a result of observing the lack of pain when the bowel was cut or otherwise traumatized concluded that the bowel was insensitive to painful stimuli and that any pain accompanying visceral stimulation resulted from irritation of the pain sensitive parietal peritoneum. It was not until 1911 that Hurst,[4] employing balloon distention of the bowel, demonstrated conclusively in man that sensation from the bowel could be elicited and emphasized the need for employing an adequate stimulus in studying visceral sensation.

Stimulation of the parietal pleura or peritoneum by friction or faradism results in pain, the impulses travelling via somatic afferent fibers in spinal nerves. But visceral pleura and peritoneum have been found insensitive to similar stimuli, and most observers have likewise found the mucosa of the stomach and bowel to lack pain sensitivity.[5, 6, 7] The stimulus adequate for the production of visceral pain is believed by many to be traction on the mesenteries, and Alvarez[6] states that neither distention nor contraction of a hollow viscus causes pain unless the adjacent mesentery is stretched. On the contrary, others[8, 9] believe that pain which results from distention of a viscus is due to stretching of its sensory nerves, while Hurst[4] and Ryle[10] contend that tension of the muscular coat or a distended or contracted viscus provides the stimulus for pain.

Many analogies can be drawn between somatic and visceral pain but certain striking differences are important to recognize for purposes of clinical investigation. Somatic pain which is conducted by spinal nerves has the property of sharpness and accurate surface localization which is largely acquired after birth, while visceral pain on the contrary is deep, dull and less well localized. But sometimes there may be a supplementary mechanism by which visceral pain is referred to a cutaneous region which has a corresponding segmental innervation. Sometimes this referred pain has been looked upon as the sole manifestation of visceral pain but blocking of the painful area locally

* Read before the Meeting of the American Surgical Association, March 25–27, 1947, Hot Springs, Va.

or interruption of the spinal nerves supplying the area by procainization cannot be counted on to abolish visceral pain.[11]

The matter of the types of end organ for visceral pain reception and their exact location is still unsettled. Tyrrell-Gray[12] (1922) advanced the view that the afferent end organs were the Pacinian corpuscles occupying the mesentery and that they responded to mechanical, thermal, chemical and electrical stimuli. Sheehan[13] (1933) summarized his studies of degeneration following section of the vagi and sympathetics by concluding that visceral pain in the abdomen arises from mesenteric nerve endings of 3 types: (1) Pacinian Bodies, (2) free endings of myelinated nerves and, (3) free endings of a fine plexus of non-myelinated fibers. The Pacinian corpuscles were found to be distributed to the mesentery of the bowel chiefly around large vessels but not in the bowel wall, and in the pancreas and about the biliary tree but not in the omentum. Splanchnicectomy resulted in degeneration of the Pacinian corpuscles.

The vagus nerves possess afferent fibers which are believed to conduct certain reflex stimuli from the abdominal viscera but not pain sensation (Cannon[14]). While some still doubt that the vagus nerves do not transmit pain impulses from abdominal viscera almost all investigators agree that the splanchnics and other sympathetic nerves do possess visceral pain fibers. The axones of the visceral afferent nerves accompanying the sympathetic nerves are poorly myelinated and their rate of conduction is slow. They run all the way to the cord without synapse and enter via the posterior spinal roots. Earlier contention that visceral afferent impulses traversed anterior spinal roots[15] has been largely discredited by later work such as that of Davis, Pollock and Stone[11] which concluded that visceral afferents enter the cord only by the posterior roots.

A table of the segmental sensory innervation of the viscera was compiled by White and Smithwick[16] (1941) from available experimental and clinical data, but much of the evidence is of necessity inferential. On the whole, comparatively few observations have been made in man on the pathways for the conduction of visceral pain. Efforts to map the spinal segments which transmit painful sensations from various levels in the gastro-intestinal tract by paravertebral injection of anesthetic agents have been described by Läwen[17] and by Kappis and Gerlach.[18] Adson[19] (1935) and Leriche[20] (1937) stimulated the splanchnic nerves in the course of operations performed during spinal anesthesia and produced pain in the upper scapular region on stimulation of the greater splanchnic, and pain lower down on stimulation of the lesser nerve. White[21] (1943) reviewed the sensory innervation of the viscera in man based on neurosurgical procedures performed for the relief of intractable pain and added an account of his own experiences.

Conclusions drawn from the results of somewhat blind injections of anesthetic agents about unseen nerves usually leave some doubt and the aggregate of experiences with alteration in visceral sensation after surgical interruption of visceral afferent nerves is relatively meager and inconclusive. For example, pain sensation originating in the heart and in the urinary bladder has received

greater attention than almost any other form of visceral sensation, yet the information is incomplete. Sympathectomy[16, 22] and posterior rhizotomy[23, 24] for relief of cardiac pain have effectively demonstrated afferent pathways through the upper 5 thoracic sympathetic ganglia and posterior roots but leave unexplained the residual pain in the neck which occurs in some patients. Learmonth's[25] investigations of bladder sensation indicate the role of visceral afferent fibers in the triple innervation of the bladder but leave unanswered the detailed pathway of the sensory fibers accompanying the sympathetic nerves.

The present study was carried out on a series of patients most of whom had hypertensive cardiovascular disease and all of whom were subjected to thoracolumbar sympathectomy in which the paravertebral ganglionated chain was resected from the seventh thoracic through the third lumbar ganglia, and the splanchnics were resected from the celiac ganglia to a point above the contribution of the seventh thoracic rami. In certain studies additional interruption of nerve pathways supplemented the standard sympathectomy. Observations were made on the pain sensitivity of the stomach, large and small intestine, biliary tree, pancreas and urinary tract prior to denervation, and at various times up to one year after right or left sympathectomy and after bilateral sympathectomy. Such tests are tedious and try the patience of both the subject and the examiner. The use of the tests and interpretation of the results require circumspection. All of the results to be reported have been observed more than once and in some cases many times, and while it is realized that additional observations are desirable the findings seem adequate at least for a preliminary report.

BALLOON DISTENTION OF THE INTESTINAL TRACT

Fifteen patients were selected for this study. A rubber bag attached to the end of a Miller-Abbott tube was passed through the mouth to various levels in the intestinal tract and the position of the bag identified by fluoroscopy.

The main cavity of the stomach because of its size and the distensibility of its wall does not lend itself readily to studies with the balloon and therefore no observations of pain by distention were made. However, the effects of temperature were studied (see section on THERMAL STIMULATION).

The *small bowel* was distended at numerous points from the duodenal cap to the cecum (Fig. 1). As a rule the pain thus induced was normally felt in a relatively discrete area somewhere in the midline between the xiphoid and the umbilicus; that from the duodenum was felt in the upper epigastrium, and that from the jejunum and ileum nearer the umbilicus. A volume of 50 to 75 cc. of air in the balloon producing a pressure of 1 to 1.5 centimeters of mercury was sufficient to cause a distinct but bearable deep aching pain. Distention to 90 to 120 cc. of air at a pressure of 1.5 to 2 cm. of mercury was perceived as a moderate to severe pain, while more than 120 cc. of air at 3 cm. mercury pressure caused severe and more widespread pain in the midline of the abdomen. Patients subjected to the latter pressure often became pallid,

developed a cold, clammy feeling and a desire to eructate. Pain did not occur in the back. While distention of the jejunum and upper ileum was always accompanied by pain at or above the umbilicus distention of the terminal ileum sometimes also caused pain below the umbilicus and occasionally about McBurney's point. This exceptional pain below and to the right of the umbilicus

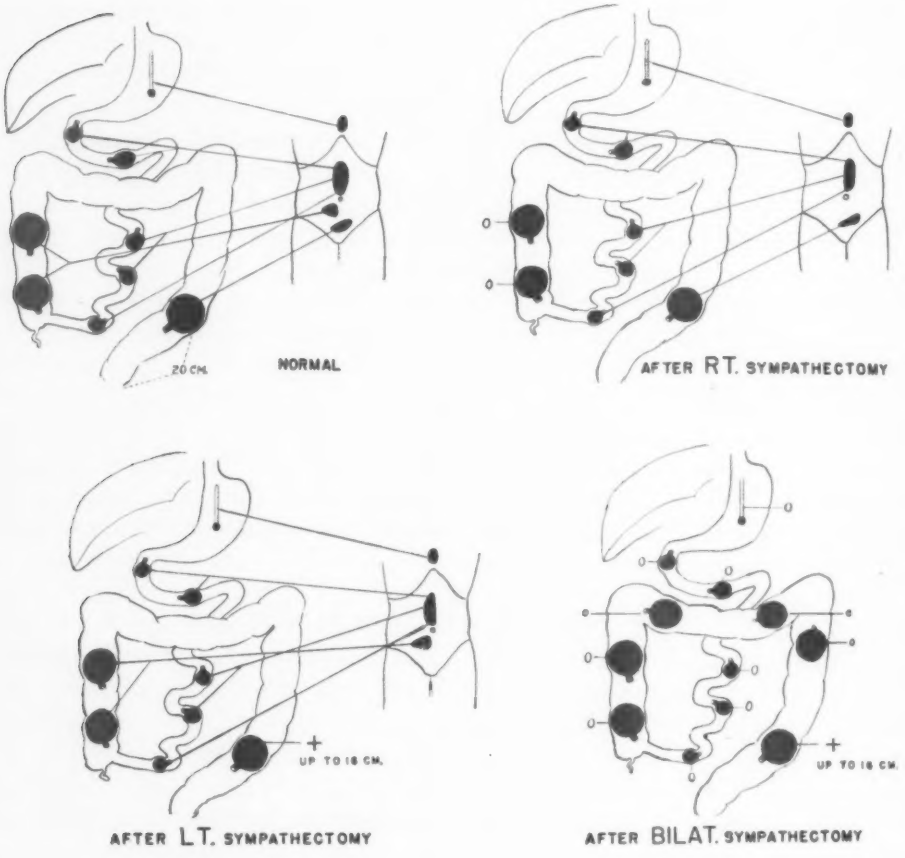

FIG. 1.—Balloon distention of gastro-intestinal tract. Eight areas of sensory reference.

did not have the deep aching character of the usual para-umbilical pain and could have occurred as a result of local parietal peritoneal stimulation or as a referred pain.

On repetition of the tests after either left or right sympathectomy, there was no alteration in the region at which pain was felt or in the threshold of

pain appreciation. There was no tendency for lateralization of the pain to the undenervated side. After bilateral sympathectomy pain could not be elicited with distention even after 300 cc. of air at 4 to 6 cm. of mercury pressure.

The *large bowel* is less satisfactory to investigate because of the difficult and unpleasant task of passing the tube and balloon the longer distance and maintaining it for the period of time necessary for the tests. However, enough observations were made to afford general conclusions. About the same pressure within the balloon sufficient to cause pain in the small bowel was adequate stimulus for pain in the large bowel with the possible exception that relatively higher pressure was sometimes needed in the cecum to cause pain of comparable degree to that from 1 to 2 cm. mercury pressure in the rest of the large bowel. The sites of pain were relatively discrete and became more diffuse only with increased pressure within the balloon. The patterns of reference are indicated in Figure 1. Normally, distention of the cecum was perceived as pain in an area just below and to the right of the umbilicus and pain arising from the hepatic flexure and proximal portion of the transverse colon occurred at points within a larger area extending from the umbilicus downward and to the right. From distention of the splenic flexure and descending colon pain was felt in the lower abdomen to the left of the umbilicus, while pain from the rectosigmoid was distributed across the suprapubic region extending perhaps more to the left side. In addition to tests with the balloon passed orally, several satisfactory observations on the lower bowel in its last 50 cm. were made using a tube with a coil spring incorporated in a #20 French catheter passed through a proctoscope. (This tube was devised by Thomas P. Almy and Fred Kern of the New York Hospital.)

After right sympathectomy the only alteration in large bowel sensation observed was absence of pain on distention of the cecum. After left sympathectomy no alteration in large bowel sensation resulted from the studies employed although in the patients examined no satisfactory observations were made of distention of the splenic flexure and descending colon. After bilateral sympathectomy the appreciation of painful distention of the large bowel was abolished above the level of 16 cm. from the anus. Below this level, distention of the bowel with the minimal adequate pressure still elicited pain in the suprapubic region. In addition, distention of this lowest segment produced a desire to defecate.

THERMAL STIMULATION

In normal subjects distention of a balloon in the stomach with water at temperatures of 110° to 120° F. caused a feeling of heat in the subxiphoid region, while water at 32° F. caused a feeling of cold in the same region. Water temperatures between these extremes were not definitely perceived and one subject did not appreciate either hot or cold. In 8 of 9 subjects examined after bilateral sympathectomy the ability to perceive temperature in the

stomach was abolished. In the ninth it persisted, but the area of reference before and after sympathectomy was at the sternal notch at the base of the neck. A few additional observations on thermal stimulation of the small bowel suggested that extremes of temperature are not perceived there but the evidence was incomplete.

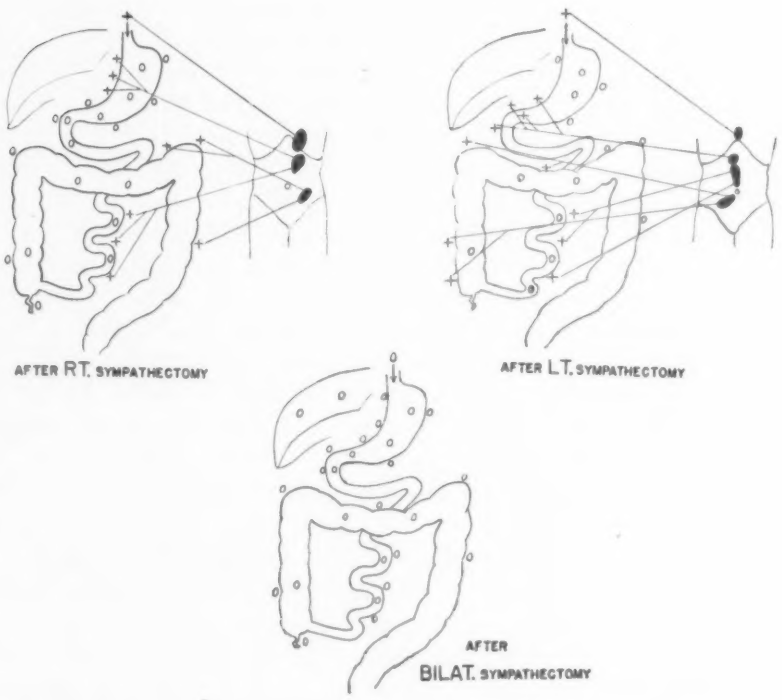

FIG. 2

FIG. 2.—Stimulation of gastro-intestinal tract (faradic, traction stretch) through celiotomy.

DIRECT STIMULATION OF THE STOMACH AND INTESTINAL TRACT THROUGH CELIOTOMY

The combined observations were made on 6 patients having unilateral or bilateral sympathectomy in whom some intra-abdominal operation was necessary. Regional procain anesthesia was employed only to open the anterior abdominal wall and peritoneum. The methods of stimulation employed included pinching and local stretching of the gastric and intestinal walls, traction on the mesenteries and omentum, and faradic stimulation of various structures. The electrical stimulation was performed with the Hinsey-Geohegan stimulator using a bipolar electrode and a current of between 3 to 5 volts. The results are diagrammed in Figure 2.

Even though tests were not made on unsympathectomized patients some

part of the gastro-intestinal tract was pain sensitive in the combined group of patients having unilateral (either right or left) sympathectomy. Pinching, local stretching, and faradic stimulation of the walls of the stomach and intestine failed to cause pain except at points close to the proximal mesenteric attachments. The greater curvature of the stomach, the gastrocolic omentum, and the greater omentum as well as the larger vessels they contain were not found to be pain sensitive. When any pain sensitivity was elicited along the gastro-intestinal tract it resulted from some form of stimulation of the mesentery or at the mesenteric attachment to the viscus.

The stomach. After right sympathectomy, traction on the cardiac end of the stomach produced pain first in the left upper abdominal quadrant. As the traction was increased precordial pain, a "tugging sensation in the gullet" and nausea were added to the abdominal pain. Traction and electrical stimulation applied to the mesentery and border of the lesser curvature of the stomach along the proximal half of its extent also resulted in pain in the left upper abdomen. Similar stimulation of the pylorus and first portion of the duodenum did not elicit pain. The reverse was found in patients after left sympathectomy, *i.e.,* the proximal half of the lesser curvature and its mesentery were insensitive while the pylorus and first portion of the duodenum were sensitive, the site of reference of the pain being in a fairly discrete area in the midline and possibly slightly to the right in the epigastrium. After bilateral sympathectomy all these positive responses of pain were abolished.

The jejunum and ileum. After unilateral sympathectomy, traction and, less constantly, electrical stimulation of the mesentery of the small bowel below the ligament of Treitz always resulted in pain in a relatively localized area above the umbilicus. After right sympathectomy the pain elicited was to the left of the midline, while after left sympathectomy the pain was in the midline or possibly slightly to the right of it. After bilateral sympathectomy no pain could be elicited from any form of stimulation of the small bowel or its mesentery.

The large bowel. After right sympathectomy traction and, less constantly, electrical stimulation of the mesentery or adjacent portion of the peritoneum (as in the case of a retroperitoneal cecum) of the colon as far as the middle of the transverse colon failed to elicit pain. The same was true of the appendix and its mesentery. But traction of the mesentery at the splenic flexure and of the descending colon (only the upper portion was examined) resulted in pain in the right lower quadrant of the abdomen. The reverse was true after left sympathectomy in that no pain followed traction on the mesentery of the left half of the colon above the pelvic brim while traction and, sometimes electrical stimulation of the mesentery of the appendix, cecum, hepatic flexure, and right half of the transverse colon elicited pain in the right lower quadrant. After bilateral sympathectomy repetition of the tests failed to produce pain when applied to any part of the colon or its mesentery above the sigmoid.

TESTS OF PAIN SENSITIVITY OF THE BILIARY TRACT AND PANCREAS (FIGURE 3)

The tests were made through the open abdomen on 6 patients who had had unilateral or bilateral sympathectomy and in whom celiotomy was necessitated because of chronic disease of the gallbladder, stomach or pancreas. In addition, observations on several unsympathectomized patients were made, sufficient to establish the adequacy of the tests and to confirm similar studies made by others on normal sensation of the biliary tract. Regional procain

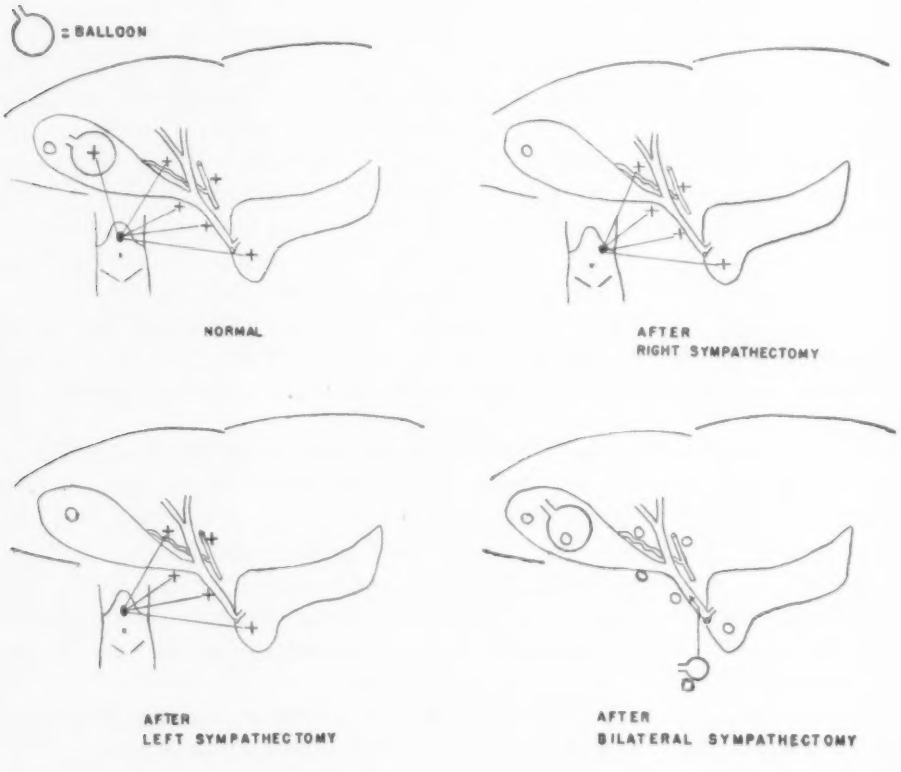

FIG. 3.—Stimulation of biliary system and pancreas stretch, faradic and distention.

anesthesia was employed to open the anterior abdominal wall and peritoneum. The methods of stimulation employed included balloon distention of the gallbladder, distention of the common duct by saline injection, and traction and faradic stimulation (3–5 volts) of all of the extra-hepatic biliary tree, the cystic vessels and the pancreas.

In the unsympathectomized patients distention of the gallbladder by inflation of the balloon with air at 4 cm. mercury pressure caused pain in a relatively small area in the midline of the epigastrium. The fundus of the

gallbladder and the capsule of the exposed liver were not pain sensitive to manipulation, local traction, or electrical stimulation. But these stimuli applied to the cystic duct, common duct, cystic artery, or head of the pancreas, each produced pain in the same spot in the mid-epigastrium. Pain did not occur in the back or in the hypochondrium.

After right sympathectomy there was no opportunity to study the effects of balloon distention of the gallbladder, but repetition of all the other tests on the biliary tract, the vessels, and head of the pancreas caused pain in the left hypochondrium. After left sympathectomy the same structures were found to be pain sensitive, but the pain was experienced in the mid-epigastrium; in addition, the pain from pressure on the head of the pancreas extended to the right hypochondrium and that from stimulation of the cystic and common ducts in one patient was experienced not only in the epigastrium but in the right infrascapular region. After bilateral sympathectomy no pain could be elicited on repetition of the tests even though the intensity of the stimuli was increased.

TESTS OF PAIN SENSITIVITY OF THE UPPER URINARY TRACT (FIGURE 4)

In 15 patients cystoscopic examinations before and after unilateral or bilateral sympathectomy permitted observations on pain sensitivity of the ureter. In the unsympathectomized subject mechanical irritation and faradic stimulation (3 volts) at the ureteral orifice and in the distal 6 cm. of the ureter caused pain over and slightly above the symphysis pubis. Rapid injection of 10 to 20 cc. of saline into the ureter (and kidney pelvis) through a #8 French ureteral catheter was very painful, the pain occurring in a broad area in the lower half of the abdomen and flank on the side stimulated. After unilateral sympathectomy the normal responses were abolished on the denervated side; there were no contralateral changes.

Two hypertensive patients undergoing sympathectomy without general anesthesia were suitably intelligent and cooperative to permit tests on the exposed kidney and upper half of the ureter. Regional procain block was used in the operative exposure of these structures and care was taken not to procainize any of the intercostal or sympathetic nerves. Faradic stimulation (up to 5 volts) of the renal capsule and pressure on the kidney at points not bordering on the renal pelvis were not painful. However pain occurred in a localized area at about the outer tip of the 12th rib on the same side when the renal pelvis, the pedicle, or the ureter near the uretero-pelvic juncture were stretched or compressed. The same type and location of pain followed faradic stimulation of these structures, including the isolated renal artery and vein. Traction and faradic stimulation of the ureter at points distal to the first several centimeters caused pain in the inguinal region on the same side. Division of the greater and lesser splanchnic nerves at the celiac ganglion and resection of the thoracic ganglionated chain from Th7 to 11, inclusive resulted in elimination of pain responses when the tests on the renal pelvis and pedicle were repeated. The pain caused

by stimulation of the ureter was not eliminated until Th12 and L1 ganglia were excised, thus extending the resection of the sympathetic chain to a point below the first lumbar ganglion.

TESTS OF PAIN AND THERMAL SENSITIVITY OF THE URINARY BLADDER

Observations on bladder sensation in several unsympathectomized patients were made in order to establish the adequacy of the tests and confirm

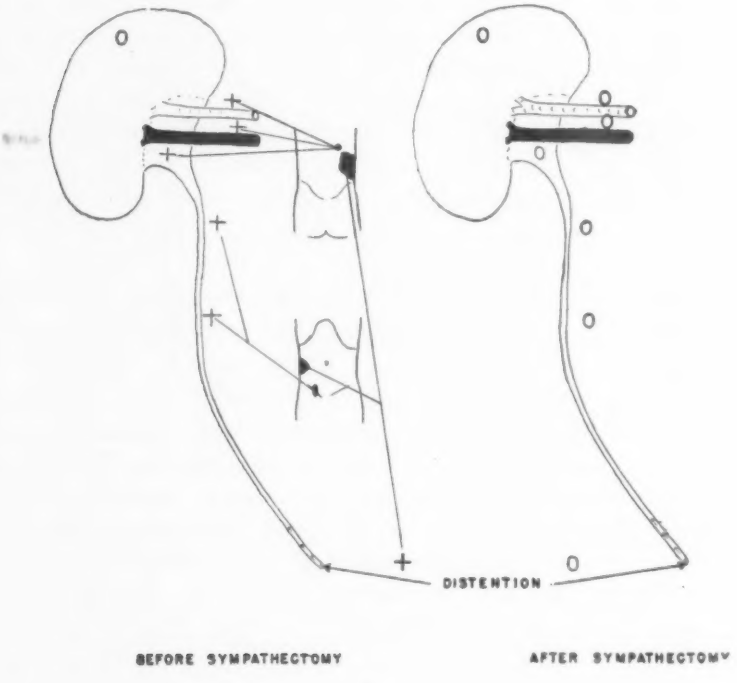

FIG. 4

FIG. 4.—Stimulation kidney, ureter and renal vessels and areas where pain is felt.

previous studies on normal bladder sensation. Faradic stimulation to the trigone (1 volt) and to the dome (2–3 volts) caused pain in the suprapubic region and over distention of the entire bladder caused similar pain. Installation in the bladder of water at 110° F. was detected as warmth in the region of the pubis while water at 65° F. or lower was perceived as cold in the same region. After right or left unilateral and bilateral sympathectomy, there was no appreciable change in these observations. The cystometric curve and bladder capacity were not altered from the normal after bilateral sympathectomy.

Additional light was thrown on the source of sensory supply to the bladder by studies on 2 patients who had had all sacral nerve roots (motor

and sensory) cut for relief of intractable pain due to malignant chordoma invading the sacrum. The bladder sensations resulting from faradic and thermal stimuli appeared normal both before and after the rhizotomies. There was urinary incontinence preoperatively and in both patients before and after rhizotomy there was a sense of suprapubic fullness after filling the bladder with 200 cc. of water and of pain after 300 cc. or more. In these patients bilateral lumbar sympathetic blocks were performed by injecting procain paravertebrally and a repetition of the tests showed that all sensation in the bladder was eliminated except a vague feeling of distress when the bladder was distended by 500 cc. or more of fluid.

Since, in the two patients subjected to complete sacral rhizotomy, the visceral afferents of the bladder accompanying the parasympathetic nerves (S2, 3, 4) and the somatic sensory fibers to the pudendal nerves (S3 and 4) were all divided, no distinction between the role of these two groups of nerves was made. However, when the pudendal nerves were blocked in the perineum by procainization in patients previously subjected to bilateral sympathectomy normal bladder responses to the standard stimuli still existed. In these patients it was assumed that the only fibers remaining to transmit sensory impulses were the visceral afferents (S2, 3, 4) accompanying the parasympathetics.

DISCUSSION

In determining any aspect of human visceral pain man has distinct advantages as an experimental animal. The opportunity for the present study was ideally provided by a selected group from several hundred hypertensive patients subjected to sympathectomy for their disease. Since the extent of the operation was believed to interrupt all or the majority of sensory nerves thought to contribute to abdominal visceral sensation, it was not unexpected to find that bilateral sympathectomy from Th7 to L3 eliminated all pain sense from the abdominal viscera (exclusive of the pelvic viscera). The study provides comparatively little information concerning the segmental innervation of the viscera but once the basic fact is established that visceral analgesia can be produced the refinements can follow. There is much to suggest, for example, that the greater splanchnic nerve plays a major role in the sensory pathway since histologically it contains a large percentage of afferent fibers and any minimal stimulation of the nerve (traction, crushing, faradism) in the unanesthetized patient causes severe and diffuse pain. Yet the study shows further that additional sympathectomy is necessary to denervate the ureter.

The balloon distention studies of the stomach and intestine in the normal are comparable in their results to those set down in Jones'[26] admirable monograph. Our postoperative balloon studies show that unilateral sympathectomy affects sensation of only the homolateral side of the colon while both sides appear to innervate the stomach and small intestine. There is a slight discrepancy between the findings in the small bowel after unilateral sympathectomy and those reported by Bentley and Smithwick[27]. The latter reported the elicited pain to be on the side of the midline away from the side of the

sympathectomy. This discrepancy is not so important, however, since the direct stimulation of the small bowel through the open abdomen after unilateral sympathectomy showed some tendency to this contra-lateralization of the pain.

Since the digestive tract is embryologically a midline structure it is not surprising that most of it appears to possess a bilateral sensory supply. It is more remarkable that the right and left parts of the colon appear to have lost their dual supply. The unusual finding of the apparent laterality of innervation of the lesser curvature of the stomach on intra-abdominal inspection is reported just as it was found; it may require additional study.

The lower end of the colon, i.e., the rectum, may have visceral sensory supply but like the oral end of the digestive tract the chief sensory supply seems to be somatic. White[21] has commented on similar findings of preservation of sensation in the lower colon following sympathectomy.

The intra-abdominal tests indicate convincingly that the pain sensitivity of the stomach and bowel is related to the mesentery or the visceral mesenteric junction and not to the remainder of the bowel wall. There has been conflict in the past on this point through the fact that Pacinian corpuscles exist almost wholly in the mesentery of the bowel had led many to doubt the existence of pain receptors except in the mesentery.

The line of demarcation anatomically between parietal and visceral peritoneum is not always certain and it has in places been arbitrarily drawn. The parietal peritoneum is usually presumed to be supplied by somatic afferents and this must be the case if one speaks of the ventral peritoneum because after bilateral sympathectomy this area possessed all its normal sensitivity. But the dorsal peritoneum overlying the head of the pancreas, for example, is also referred to anatomically as "parietal" in spite of the fact that it possesses Pacinian corpuscles[28] and loses its pain sensitivity after bilateral sympathectomy.

The appreciation of temperature in the stomach has been investigated by Wolf and Wolff[7]. Working with a man who had possessed a gastric fistula for many years they found that water in a 10 cm. bag in the stomach could be identified as hot and cold above or below 40° to 18° C., and beyond these extremes, variations of 3 degrees could be detected. The subject described the sensation as an area the size of his fist deep in the epigastrium but when the balloon was placed near the lower end of the esophagus a more intense sensation was elicited which was felt in the substernal area. Our observations tend to corroborate theirs and also to show that temperature sense (always closely allied with pain sense) is eliminated from the stomach by interruption of the sympathetics.

Past studies on sensation of the extra-hepatic biliary tract[29, 30, 31, 32, 33], as well as the present ones, show agreement in the area of constant reference of pain in the epigastrium. The occurrence of associated pain in the back in some subjects appears to be dependent on stimulation of the ducts, possibly at the sphincter of Oddi. The work of Davis, Pollock and Stone[11] shows that sensation in the gallbladder of dogs is supplied exclusively by the visceral

afferent nerves accompanying the sympathetics and more particularly the right splanchnic. Our studies in man show that the extra-hepatic ducts possess a bilateral sensory innervation although there were no observations on the results of distention of gallbladder after either right or left unilateral sympathectomy. Even though this item of information is lacking, it is fair to assume that in man the gallbladder too has a bilateral innervation and this assumes practical importance if nerve sections are to be put to use in the relief of pain.

The head of the pancreas has also been found in our studies to have a bilateral innervation. The importance of this finding was exemplified in a patient who had intractable pain from chronic calcareous pancreatitis of several years' standing. Her initial pain was in the mid-epigastrium and back. After right-sided resection of the splanchnics and ganglionated chain from the seventh thoracic to the third lumbar the former pain disappeared but pain of less degree now existed in the left hypochondrium. This left-sided pain was enhanced or duplicated by extra-abdominal pressure over any part of the palpable pancreas and in addition discretely localized stimulation (pressure and faradism) of the head of the pancreas after right sympathectomy caused left-sided pain. Following a left-sided sympathectomy all spontaneous pain ceased and no tenderness could be elicited on pressure over the previously tender gland (postoperative follow-up, 9 months).

The unilaterality of the sensory supply of the kidney and ureter from the evidence of these studies is definite and there is the additional suggestion that nerves other than the splanchnic play a role in sensory transmission at least for the ureter.

The investigations of Learmonth[25] led to his formulation of the triple sensory supply to the urinary bladder. Visceral afferents of the sympathetic system traverse the hypogastric nerves and plexus and the lumbar ganglionated chains. Visceral afferents of the parasympathetic system traverse the pelvic nerves which have their origins from the 2nd, 3rd and 4th sacral nerves. The somatic afferents traverse the pudendal nerves which originate from the 3rd and 4th sacral nerves. Our observations indicate that the interruption of any of the following nerve supply will not eliminate bladder sensation: bilateral lumbar sympathetics; parasympathetics, and pudendals (by section of all sacral nerve roots); bilateral lumbar sympathetics and both pudendal nerves. But interruption of all these will result in an insensitive bladder.

While the incentive to carry out these investigations was motivated primarily by a desire to learn something more about visceral sensation, some concern existed regarding the possible undesirable effects of the sympathectomies now being performed on so many patients with hypertensive cardiovascular disease. There is little doubt that after a bilateral thoracolumbar sympathectomy the visceral pain component of many abdominal diseases will be absent but in the most important ones (those, for example, that cause the acute surgical abdomen) there should always be other symptoms and signs. In two of our patients who had had bilateral thoracolumbar sympathectomy peptic ulcers perforated without there being any previous pain of the ulcer

but the patients vomited and showed all the signs of acute peritonitis which led to early diagnosis and successful operation. So far none of the several hundred sympathectomized patients of our series is known to have developed acute appendicitis, cholecystitis, or any other abdominal surgical disease. However, it is now our practice to perform cholecystography on most patients who are to undergo sympathectomy for hypertension; if gallstones are discovered cholecystectomy is advised unless otherwise contraindicated.

CONCLUSIONS

Studies of visceral sensation before and after sympathectomy in which the splanchnics and ganglionated chains are removed from Th7 to L3 on one or both sides show the following:

1. Pain sense in the stomach, intestine (except the rectum), extrahepatic biliary tract, pancreas, kidney, and ureter is mediated wholly by visceral afferent nerves which accompany sympathetic nerves within the area of the operative excision.

2. The kidney and ureter and the two sides of the colon have a homolateral sensory supply, but the remaining organs, with the possible exception of the gastric mesentery, have a bilateral supply.

3. Pain sensitivity exists not in the walls of the stomach and intestine but in the proximal mesenteries and at the mesenteric-visceral juncture.

4. Adequate stimuli for pain include, distention of hollow viscera; traction and faradic stimulation of stomach and intestinal mesenteries; manipulation, traction, faradic stimulation of the extrahepatic biliary tract, pancreas, kidney pedicle and ureter.

5. There is perception for extremes of temperature in the stomach; the afferent pathway accompanies the sympathetics.

6. The urinary bladder has a triple sensory supply via the visceral afferents of the sympathetic and sacral parasympathetic systems and the somatic pudendal nerves.

7. Interruption of appropriate sympathetic nerves may be employed for relief of intractable pain from some types of abdominal visceral disease.

8. The extensively sympathectomized patient due to the loss of visceral pain sense may undergo certain alterations in his response to visceral disease.

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DISCUSSION.—DR. LESTER R. DRAGSTEDT, Chicago: I should like to congratulate Drs. Ray and Neill on this interesting and, I think, very important contribution. Physiologists have felt for some time that the sense of hunger is due to contractions of the empty stomach.

The sensation of hunger is apparently not abolished by complete section of the vagus nerves to the stomach. I should like to ask the authors if they have made any observations on the hunger sense in patients following extensive sympathectomy. I am interested in the report that sympathectomy produces complete relief of ulcer distress. This observation corroborates the work of the earlier French surgeons. We have observed a similar complete disappearance of the typical ulcer pain and distress following complete section of the vagus nerves to the stomach. Following this operation, however, the typical distress can be reproduced again by introducing 200 cc. of .5 per cent hydrochloric acid into the stomach. I should be interested to know if the authors have performed such an acid test on patients with peptic ulcer who have undergone extensive sympathectomy.

Dr. Frederick L. Reichert, San Francisco: Dr. Bronson Ray has talked about thoracolumbar sympathectomy. I am not sure if I know what he is talking about; is he referring to splanchnicectomy and thoracolumbar sympathectomy, or each alone? If he had done splanchicectomy and made these observations it would be important. This should be made clear, otherwise things are mixed up. I am glad to hear Dr. Dragstedt say these patients had pain after vagotomy when hydrochloric acid was given.

Dr. Wm. Babclay Parsons, New York: Last year in the discussion of Dr. Whipple's paper on radical pancreatectomy for pancreaticolithiasis, Dr. Smithwick reported thoracolumbar sympathectomy in one case. I think the result reported by Dr. Ray is most interesting, but I believe it emphasizes the very important decision which must be made as to the type of therapy required in these cases. We recently had a young man of 22 with intractable pain and beginning morphine addiction due to pancreaticolithiasis in the head of the pancreas. A radical operation removing the head of the pancreas was done. He made an uneventful recovery from the operation. He has gained 30 pounds in weight and his condition is most satisfactory. I would like to question whether he is not better off now, having had the head of his pancreas removed, with the duodenum, than he would be were he robbed of a considerable portion of his visceral sensation for the rest of his life.

Dr. Loyal Davis, Chicago: Drs. Ray and Neill are to be congratulated on this very fine piece of physiologic work in visceral pain carried out upon the human. They have corroborated the work which was first done experimentally in our surgical laboratory and later extended in our studies upon visceral pain. Experimentally, we could stop all evidences of pain in the cat, produced by distention of the common duct and gallbladder, when the right splancnic nerve or the right thoracic sympathetic trunk were removed. It was very clear to me what Dr. Ray stated that they did in their experiments and the portions of the sympathetic system removed in their patients.

Dr. Bronson S. Ray, New York (closing): It is our belief, Dr. Dragstedt, that following bilateral thoracolumbar sympathectomy, or even total sympathectomy, patients still have hunger sensation. I was also aware that the interruption of the vagi has no apparent effect on hunger and neither of them prevents nausea and vomiting. It has been my hope that we might have a suitable case for study in which both the sympathetic and vagus supplies to the stomach were interrupted. Until such a case is studied, it is impossible to draw final conclusions. With regard to the induction of gastric pain by the administration of acid, we have not employed that test in our sympathectomized patients but shall do so.

In answer to Dr. Reichert's criticism, I would repeat that this study of visceral sensation was made on a group of patients who had had unilateral or bilateral thoracolumbar sympathectomy for treatment of hypertension. In each case the ganglionated chain was removed from the seventh thoracic to the third lumbar, and the greater splanchnic nerve was resected between the celiac ganglion and a point above the contribution of the seventh ramus.

THE ROLE OF PINEALOMAS IN THE CAUSATION OF DIABETES INSIPIDUS*

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SINCE THE ORIGINAL INVESTIGATIONS on the antidiuretic effect of the secretion of the posterior lobe of the hypophysis by von den Velden[1] (1913), and the causation of polyuria following lesions of the hypothalamus by Camus and Roussy[2] (1913), the occurrence of diabetes insipidus in some patients with pituitary tumors or other lesions in the immediate suprasellar or chiasmal region was easily understood. On the other hand, the occasional report of marked polydipsia and polyuria in patients with tumors arising from the pineal body and apparently confined to this area which is so far removed from the supposed source of diabetes insipidus, was until recent years, incapable of explanation. In some reports of pineal tumors in patients having a high water intake and output a second tumor in the pituitary region was presumably the cause of the water imbalance (Horrax and Bailey,[3] 1925), but in other observations where no second lesion was found the diabetes insipidus was thought to be due to indirect pressure on the hypothalamus from internal hydrocephalus (Martin,[4] 1923).

As to the actual intracranial area responsible for polydipsia and polyuria, there were until very recently three theories, namely, that it was caused by a lesion of the posterior lobe of the pituitary gland, by injury to the hypothalamus, especially the tuber cinerea, or by interruption of a tract of demonstrated nerve fibers running from the hypothalamus through the pituitary stalk to the posterior lobe of the gland, the so-called supra-optico-hypophyseal tract. Futcher[5] summarized the situation in 1931 as follows: "The tentative conception is that the nucleus supra-opticus is the centre that presides over the normal regulation of water balance. The fact that this centre is connected by a definite bundle of fibres with the posterior lobe, the extract of which has such a potent effect in relieving the polyuria of many cases of diabetes insipidus, seems to be of the greatest significance . . . the existence of this tractus supraoptico-hypophyseus . . . renders it probable that diabetes insipidus may result from lesions anywhere along its course as suggested by Zadek."

This theory was confirmed some ten years later when, according to Jones,[6] the work of Fisher, Ingram, Ranson and their associates from 1935 to 1941 reconciled the previously opposing views. Jones states: "It has been shown that there exists a hypothalamicohypophyseal system, with an included supraopticohypophyseal tract, which operates as a functional unit, and

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that injury to any part of this system causes diabetes insipidus. . . . Since secretion of the antidiuretic principle by the pars nervosa (of the pituitary) is dependent on innervation through this tract, the supraopticohypophyseal tract is a functional unit, and injury anywhere along this tract may result in diabetes insipidus."

It was not until the publication of the important case report by Stringer[7] in 1934 that the role of pinealomas in the causation of polydipsia and polyuria was correctly explained. This author studied a patient coming to autopsy, and found in addition to a small pinealoma replacing the pineal body, a solitary implant confined to the tuber cinereum of the hypothalamus (Fig. 1).

FIG. 1.—Pineal tumor implant in hypothalamus (just posterior to optic chiasm, C). (From Stringer, S. W., Yale J. Biol. and Med.)

Martin and Davis[8] (1941) studied eighteen cases of pineal tumor in the Cushing Tumor Registry and stated that diabetes insipidus was present in 8 of these patients. They found implantations or "seedings" of the pineal tumors in many cases involving the pituitary body, the walls and floor of the third ventricle and the periaqueductal gray matter, but from such widespread implantations no support could be given to any theory as to a localized area responsible for the disturbance in water balance.

In the article already mentioned by Horrax and Bailey[3] there were twelve histologically verified cases of pinealoma from Cushings' clinic. Three of these patients showed well-marked diabetes insipidus, but in two of them a second tumor of totally different microscopic type involving the hypothalamic region was unquestionably the source of the fluid imbalance. In the third case, only a tumor in the pineal region was assumed at the time to be present (Fig. 2), but it is quite likely that if sections from the floor of the

third ventricle or of the pituitary stalk had been studied microscopically, invasion of these areas by pinealoma cells might have been disclosed as in Case 1 of the patients recorded here.

The diagnosis of pinealoma or a tumor arising from the pineal body has been made in 17 instances in the writer's brain tumor series during the past 14 years.

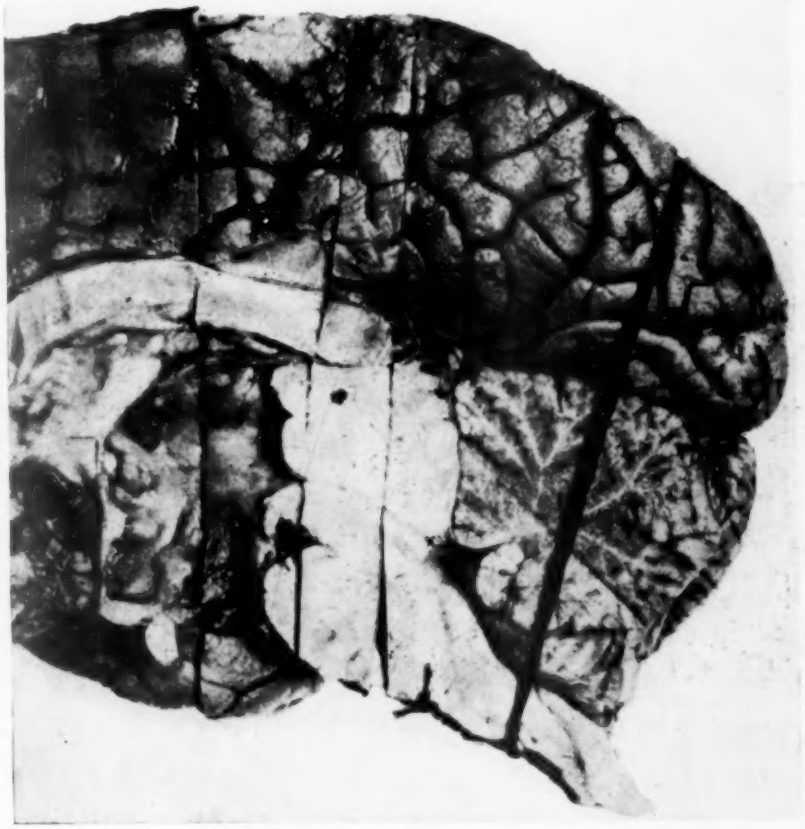

FIG. 2.—Pineal tumor with associated diabetes insipidus without gross involvement of hypothalamic region. (From Horrax and Bailey, Arch. Neurol. and Psychiat., 1925.)

In 12 of the patients the tumor was verified histologically either at operation or at autopsy. In the other five patients histologic verification has not as yet been possible, but in these cases localizing neurological signs combined with the visible ventriculographic evidence of a tumor projecting into the posterior portion of the third ventricle from the pineal region has certified the diagnosis beyond any reasonable doubt.

Of the total 17 patients five have shown well-marked diabetes insipidus. Two of these patients have been in the group with histologically verified tumors, the lesion in the other three having been demonstrated by ventriculography. In one patient with histologic verification at autopsy the tumor from

the pineal region was shown to have extended through the floor of the third ventricle to involve the hypothalamus and pituitary body, thus explaining the presence of the polyuria. The other patient whose lesion was verified microscopically, had a so-called "ectopic" pinealoma in the area above the sella turcica without clinical or other evidence of a growth in the pineal region. The

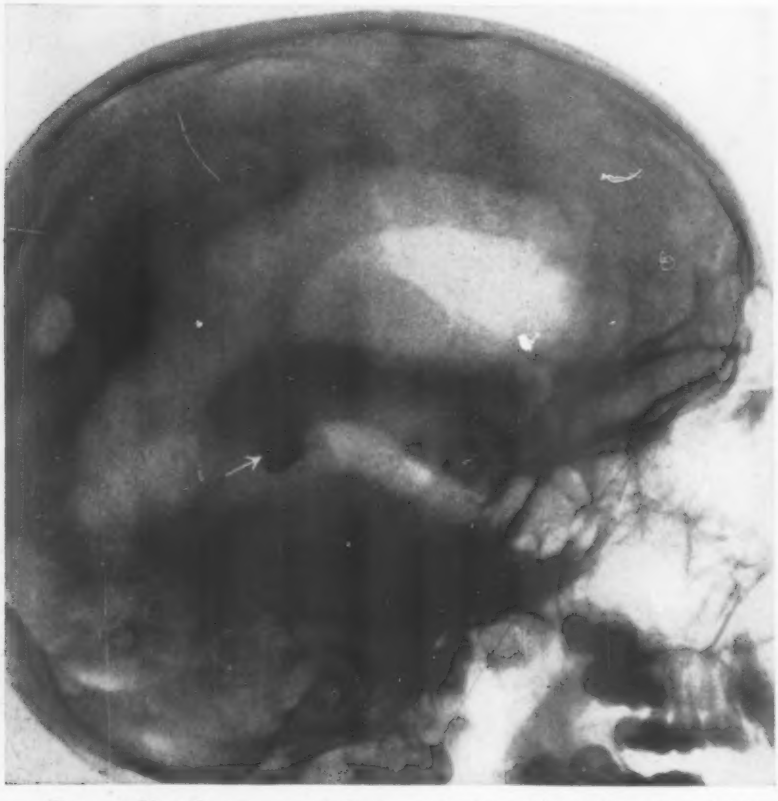

FIG. 3.—Ventriculogram of Case 1, showing dilated lateral ventricles, large calcification in pineal region and curved shadow of tumor just anterior to calcification bulging into third ventricle.

diabetes insipidus in this patient was, of course, easily explainable, as in other tumors situated in the neighborhood of the pituitary stalk and contiguous structures. The tumor was removed at operation and the patient's polyuria has been greatly benefited.

The three patients whose tumors were demonstrated by ventriculography have all had roentgen therapy directed at the pineal region. In one of these patients there has been a significant reduction of the fluid intake and output, and excellent control of the residual situation can be maintained by the use of extremely small amounts of pitressin powder snuffed up the nose. This improvement may be due to the fact that the area covered by the roentgen treatment included a portion of the anterior third ventricle and hypothalamic

region. The other two patients still show a rather marked polyuria but both have accustomed themselves to their difficulty. One of them has received further courses of roentgen therapy directed both toward his pineal and suprasellar areas with no appreciable change in his intake and output.

REPORT OF CASES*

Case 1.—*Partly calcified pinealoma in a child 12 years of age. Diabetes insipidus. Death following exploration of pineal region. Extension of tumor through floor of third ventricle into hypophysis.*

This child, P. P., was referred by Dr. Harvey Cushing and was admitted to the New England Deaconess Hospital on July 7, 1936. During the year previous to this the patient had been drinking large quantities of water and voiding similar large amounts of

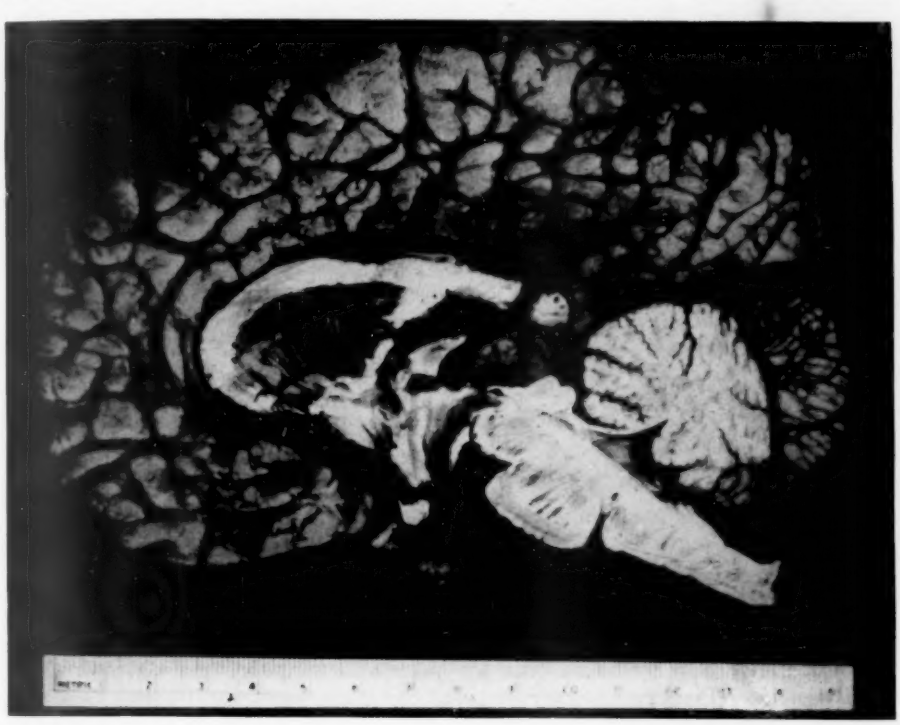

FIG. 4.—Median sagittal section of brain in Case 1. Pineal tumor between posterior end of corpus callosum and corpora quadrigemina protruding into third ventricle. (This and Figs. 5 and 7 to appear also in J. Neurosurg.)

urine. The 24-hour amounts measured at the New Haven Hospital ranged from 3,350 to 4,625 cc. intake and 4,100 to 4,350 cc. output. The specific gravity of urine was 1.008. One month prior to his admission to the Deaconess Hospital the child had developed symptoms of increased intracranial pressure. Neurological examination was negative. A ventriculogram on July 8, 1936, disclosed dilated ventricles, a large pineal calcification and

* The records of four of the cases reported here have been utilized previously from other standpoints. An article incorporating Cases 1 and 2 has been accepted for publication by the Journal of Neurosurgery. Cases 3 and 4 were published as Cases 3 and 4 of the following article: Horrax, Gilbert and Daniels, J. T.: The conservative treatment of pineal tumors. Surg. Clin. N. Amer., **22**: 649–659, 1942.

the projection of a tumor mass into the posterior portion of the third ventricle (Fig. 3). A transventricular operation on the same day was undertaken to try to remove the growth but this was unsuccessful and the patient died three days later.

Pathologic Studies. These were made by Dr. Louise Eisenhardt, of the Cushing Tumor Registry, New Haven, to whom I am greatly indebted not only in this instance but also in Case 2.

A median sagittal section of the formalin fixed brain showed the gross relationships of the tumor in the pineal region (Fig. 4). This was microscopically a typical pinealoma (Fig. 5).

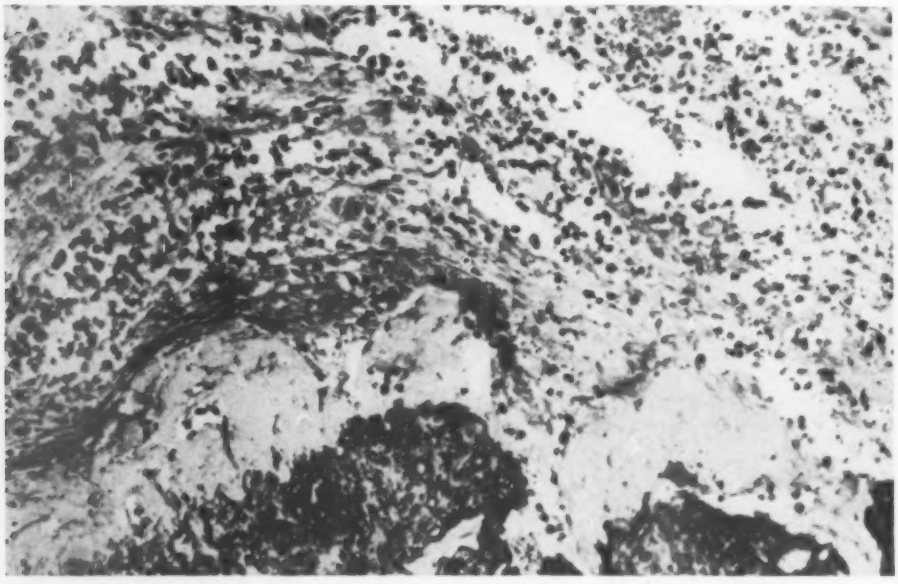

FIG. 5.—Photomicrograph of pinealoma surrounding calcification (lower part of figure) in Case 1. (× 150)

Because the patient was known to have had diabetes insipidus, Doctor Eisenhardt made sections of the floor of the third ventricle and of the hypophysis, and both were shown to be invaded by pinealoma cells, the invasion in the pituitary being confined to the posterior lobe (Fig. 6).

Discussion. Although the lesion causing polyuria in this patient was not quite as discrete as in Stringer's case where the pinealoma implant was confined to the tuber cinerea, nevertheless the invasion of the hypothalamic-hypophyseal tract was extremely localized and therefore highly significant as supporting clinically the experimental work referred to previously in the quotation from Jones.

Case 2.—*"Ectopic" pinealoma in the suprasellar region in a child of 12. Diabetes insipidus. Operative removal of tumor followed by roentgen therapy. Excellent clinical result with marked improvement in polyuria.*

The patient, S. F., was referred by Dr. H. Magendantz, of Boston, and admitted to the New England Deaconess Hospital on February 2, 1942. He had developed an excessive thirst and urinary output about two months prior to admission necessitating his

getting up three or four times at night to void. His 24-hour urinary output in the hospital was 3,140 cc.; the specific gravity of the urine varied from 1.003 to 1.012.

Aside from general physical underdevelopment there were no significant neurologic findings, but roentgenograms of the skull showed a distinctly enlarged sella turcica with depression of the floor into the sphenoid sinus.

It was assumed that the child had a craniopharyngioma and on February 3, 1942, a right frontal craniotomy disclosed a solid tumor situated between the optic nerves. A very complete extirpation of the tumor was accomplished, and the child made an uneventful convalescence.

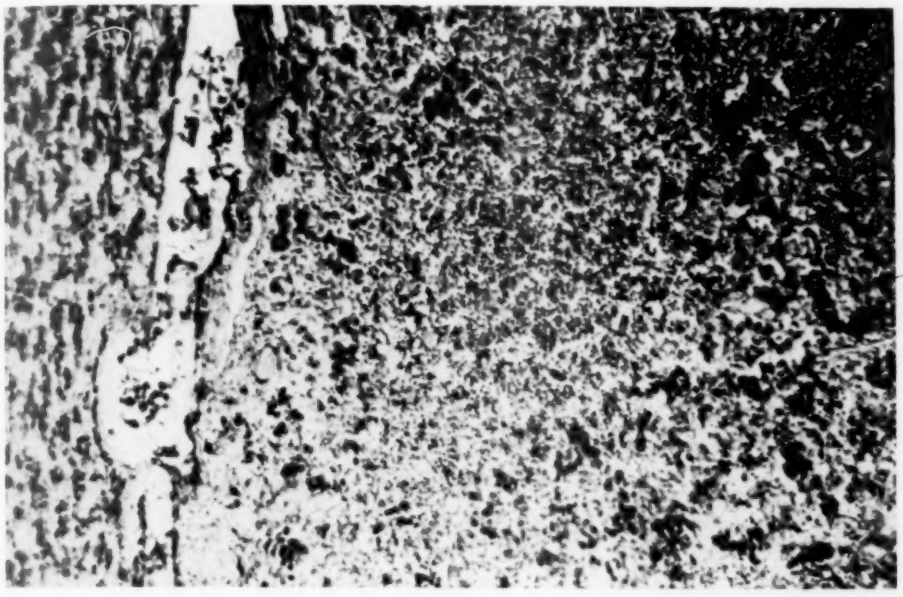

FIG. 6.—Pinealoma (at right) invading posterior lobe of pituitary (center): normal anterior lobe at left: Case 1 (× 150).

Because the original pathologic report on the tumor had indicated that it was probably a malignant growth of testicular origin the patient received postoperatively 12,000 r units of roentgen therapy through several ports directed toward the suprasellar region. No evidence of a tumor in the genito-urinary system was disclosed clinically.

Sections of the tumor were subsequently sent to Doctor Eisenhardt and she established the diagnosis of ectopic pinealoma (Fig. 7).

Subsequent Course. This patient is alive and well, attending school regularly, five years and two months since his operation. He now drinks about 12 glasses of water a day compared to 17 to 20 glasses a day preoperatively. He voids only once at night compared to three or four times before operation.

Discussion. The occurrence of diabetes insipidus in this case occasioned no surprise since the only evident clinical lesion was in the suprasellar region. The microscopic diagnosis of a pinealoma was, however, most unexpected. Whether the tumor is an isolated ectopic growth or whether it had its origin from a tumor in the pineal region which has never manifested itself clinically is obviously as yet undeterminable. It is likewise open to question whether

the operative removal of the tumor or whether the heavy course of roentgen therapy played the major role in the patient's recovery and in the subsidence of his diabetes insipidus.

Case 3.—*Pineal tumor demonstrated by ventriculogram in a young man of 20. Diabetes insipidus. Roentgen therapy. Subjective improvement.*

B. N. was referred by Dr. Alexander Marble, of Boston, and was admitted to the New England Deaconess Hospital on May 28, 1939. He had been drinking excessive quantities of water and voiding similar amounts of urine for eight or nine months. He had likewise had severe headaches and "fainting" spells for a similar period.

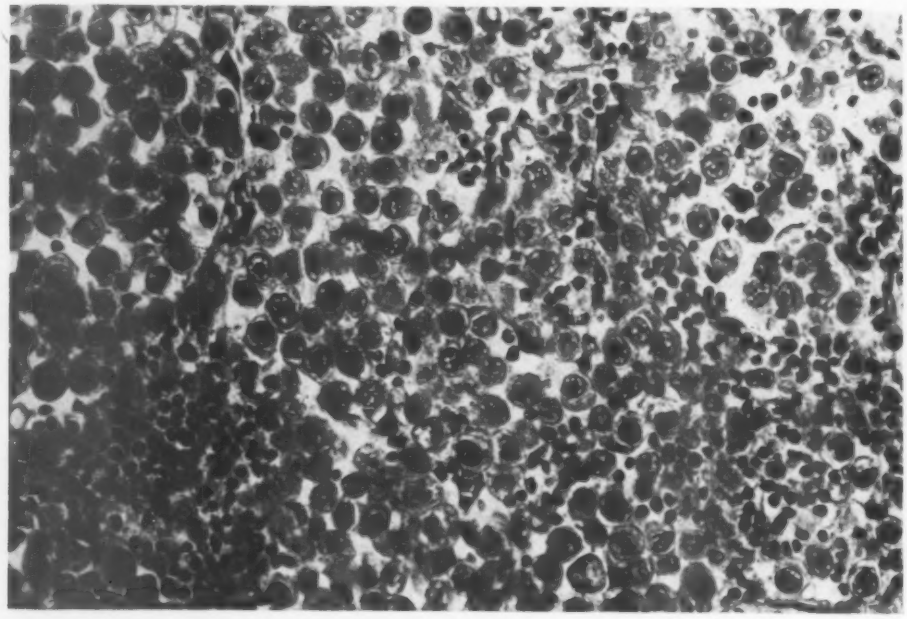

FIG. 7.—Typical pinealoma with large, pineal parenchyma cells and small lymphoid cells. Case 2. (× 400)

His measured 24-hour fluid intake in the hospital varied from 4,600 cc. to 6,450 cc. and his output from 3,700 cc. to 7,800 cc. The specific gravity of the urine varied from 1.003 to 1.014.

Neurologic examination disclosed limitation of conjugate movement of the eyeballs above the horizontal plane; his pupils were unequal, the right being larger than the left, and neither pupil reacted to light although they did react to accommodation.* His fundi showed slight edema of the optic disks.

By the use of pituitary powder in the nose his fluid intake could be reduced temporarily to between 1,380 and 1,440 cc. and his output to between 1,590 and 2,100 cc.

On June 26, 1939, a ventriculogram was made because of his intracranial symptoms and showed dilated lateral ventricles with a rounded mass protruding into the posterior portion of the third ventricle (Fig. 8).

In view of the patient's relatively normal fundi no decompression was performed in this case, and between July 5 and August 3, 1939, he received ten roentgen treatments for a total of 1750 r units delivered through two ports. After the first treatment he became

* These are the usual neurologic findings in patients having pineal tumors.

violently ill with nausea and vomiting so that the treatments had to be suspended temporarily. They were then resumed and by July 6 he showed distinct improvement in headaches. On July 22 the conjugate movement of his eyeballs upward was nearly normal. He was discharged on July 23, 1939.

Discussion. This patient has been seen at intervals since he left the hospital and his general health had remained excellent when last seen August 16, 1946, seven years after his roentgen therapy. From the time of his discharge his

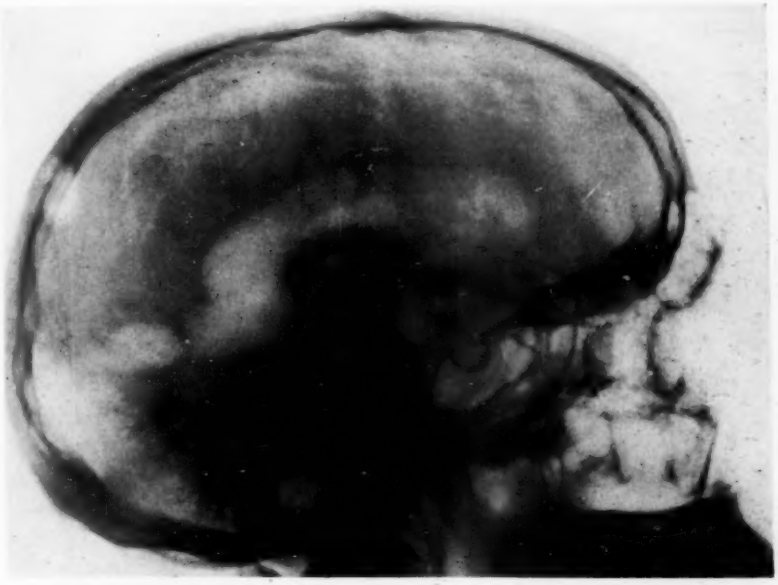

FIG. 8.—Ventriculogram of Case 3. Arrows point to rounded projection of presumed pineal tumor in posterior portion of third ventricle. Lateral ventricles somewhat dilated. (From Horrax and Daniels, Surg. Clin. N. A., 1942.)

diabetes insipidus could be controlled with a smaller amount of pitressin or pituitary powder than before his roentgen treatments. He has, however, for the most part discontinued the use of these products and has accommodated himself to the excessive intake and output. At his last report in 1946 he stated that he was drinking and voiding about 10 quarts of fluid per day whereas four years previously he stated that these amounts were about 16 quarts.

Case 4.—*Pineal tumor demonstrated by ventriculogram in a male of 24. Diabetes insipidus. Decompression and roentgen therapy. Marked improvement.*

C. B. was referred by Dr. H. N. Kelly of Worcester, Massachusetts and was admitted to the New England Baptist Hospital on December 11, 1940. He complained of inordinate thirst and excessive urination over a period of seven weeks. He also had blurred vision and severe headaches. The patient stated that his fluid intake and output varied from 12 to 16 quarts per 24 hours. This could be reduced considerably by the use of pituitrin powder snuffed up the nose. The specific gravity of his urine varied from 1.003 to 1.005.

Neurologic examination showed early papilledema, pupils which reacted poorly to light, and impaired conjugate movement of the eyeballs above the horizontal plane.

On December 13, 1940, a ventriculogram disclosed dilated lateral ventricles with a rounded shadow bulging into the posterior portion of the third ventricle from the pineal region (Fig. 9). A right subtemporal decompression was carried out the same day.

Between December 26, 1940, and January 6, 1941, when he was discharged, the patient received nine roentgen treatments directed at the pineal region, through three portals for a total of 2,700 r units. He was considerably improved and relieved of all pressure symptoms on leaving the hospital.

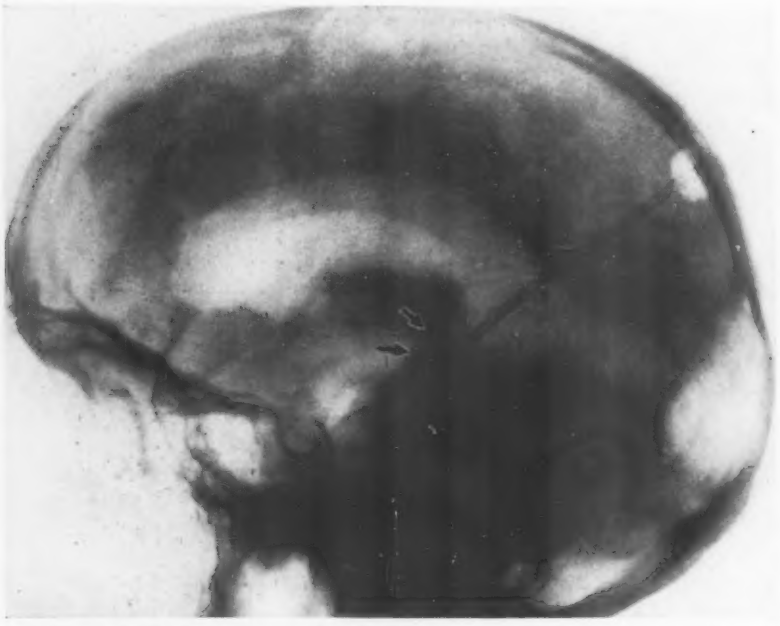

FIG. 9.—Ventriculogram of Case 4. Arrows indicate curved outline of presumed pineal tumor projecting into posterior portion of third ventricle. Lateral ventricles dilated. (From Horrax and Daniels as in Fig. 8.)

Discussion. This patient has reported by letter and in person on many occasions since his operation and roentgen therapy. His general health has remained excellent.

His fluid intake and output has stabilized at six to eight quarts for the 24 hours. In his own words, "To maintain this degree of water balance requires the smallest possible amount of powdered posterior pituitary that can be placed on the small end of a toothpick. Between two to three hour intervals for these doses remains about constant." This letter was dated March 10, 1947.

The patient reported in person on March 18, 1947. He was in excellent condition with an entirely negative neurologic examination.

In respect to his diabetes insipidus he volunteered that he felt sure his excessive fluid intake had become somewhat of a habit with him since when water was not easily accessible the amount of his intake and output was cut down one third to one half for days at a time. There is no doubt, therefore,

that he has had great relief from this condition as a result of his roentgen therapy.

Case 5.—*Pinealoma demonstrated by ventriculogram in a male of 31. Development of diabetes insipidus nine years after decompression and roentgen therapy.*

R. M. was admitted to the Peter Bent Brigham Hospital on October 24, 1932, complaining of headaches, vomiting and blurring of vision of six weeks' duration. Neurological examination showed bilateral choked disks of 3 to 4 diopters. His pupils were unequal and reacted sluggishly to light and accommodation.

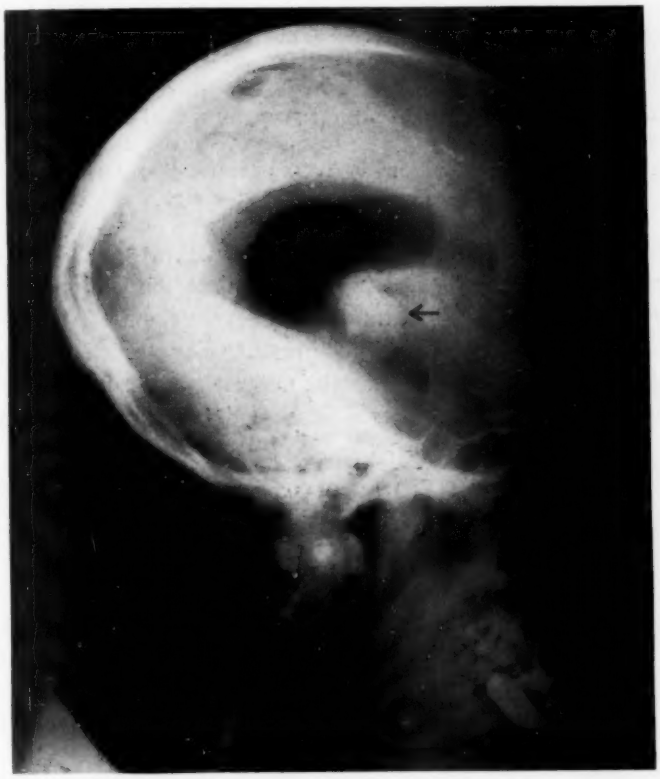

FIG. 10.—Ventriculogram of Case 5. Large tumor shadow (arrows) presumed pinealoma, bulging into posterior portion of third ventricle. Lateral ventricles dilated. (Kindness of Dr. M. C. Sosman.)

A ventriculogram October 26, 1932, showed marked dilatation of the lateral ventricles with a convex projection into the posterior portion of the third ventricle from the pineal region (Fig. 10). On October 28, 1932, a right craniotomy with decompression was carried out by the writer, the idea at that time being to allow the ventricle to expand still further in order subsequently to do a transventricular approach to the pineal tumor. This fortunately has never been necessary.

Following his operation the patient was given five series of roentgen treatments from November 1932 to March 1934 by Dr. M. Sosman, who has kindly supplied the dosage and has allowed me to obtain a print of the ventriculogram. Each series consisted of four treatments of 750 r units to either side of the head, directed toward the pineal region,

a total of 1,500 r units per series. The patient was discharged November 14, 1932, with all symptoms relieved.

He remained well for nine years until December 1941 when he developed a severe diabetes insipidus which was helped to some extent by injections of pitressin in oil. Between January 7, 1942 and March 17, 1942 he was given further roentgen therapy; 1,000 r units were delivered to the suprasellar region and the same amount to the pineal area. However, his intake and output has averaged 3,500 cc. each per 24 hours and it is necessary for him to attach a urinal at night. The specific gravity of the urine varied from 1.002 to 1.010.

He reported in person on March 24, 1944. His fundi were normal except for slight secondary atrophy; his pupils were equal and reacted well to accommodation and fairly well to light. His ocular movements were normal and his decompression was flat. He reported again on June 15, 1944 after a trial of pitressin powder snuffed up the nose but this had not influenced his polyuria. He was then given a second series of roentgen treatments, 600 r units being delivered to three ports for a total dosage of 1,800 r, directed toward the suprasellar region.

A letter from the patient on March 10, 1947 states that his measured intake and output per 24 hours is still approximately 3,500 cc. for each.

Discussion. Aside from the long useful survival (14 years) following decompression and roentgen therapy for a patient with neurologic and ventriculographic evidence of pineal tumor, the development of diabetes insipidus nine years after his original intracranial pressure symptoms is interesting. He, like the others in whom the water intake and output is troublesome, is nevertheless at his usual work and has accommodated himself to the handicap very well.

SUMMARY

Diabetes insipidus has been present in two patients with histologically verified pineal tumors and in three other patients in whom such a tumor has been demonstrated beyond reasonable doubt by neurologic and ventriculographic evidence. In one patient (Case 1) the tumor cells were shown microscopically to have invaded the hypothalamus and posterior lobe of the pituitary body, thus involving the tract of nerve fibers interruption of which has been shown to be responsible for diabetes insipidus. In Case 2, the growth was an ectopic pinealoma in the suprasellar region obviously compressing the area in question and when this tumor was removed operatively the polyuria was greatly lessened.

In the three patients whose tumors have been depicted by air studies a similar invasion of this tract, as in Case 1, seems probable. These three patients have received roentgen treatment in two of whom the rays were directed not only at the pineal region but also to the suprasellar area which included the hypothalamic region as well. Their general condition has remained excellent for six and one-half to 14 years following roentgen therapy. The diabetes insipidus has been considerably relieved in one and probably in two of these patients. It is possible that the water imbalance may persist because partial interruption of the nerve tract from hypothalamus to pituitary is permanent even though the tumor cells originally causing this interruption have been destroyed by the roentgen rays.

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DISCUSSION.—DR. PETER HEINBECKER, St. Louis: The interrelationships of the hypothalamus and the hypophysis are so complex that it is not possible always to interpret them from clinical material. We must have recourse to the experimental laboratory for knowledge necessary to understand the mechanism of diabetes insipidus associated with tumors in the region of the pineal and in the region of the hypothalamus itself. Experimental work to determine the essential lesion in diabetes insipidus has been in progress in our laboratory for years. As a result of these studies, the following conclusions are permissible:

1. Experimental diabetes insipidus in dogs follows destruction or denervation of the entire neurohypophysis; all the cells of paired supraoptic neuclei and the rostral half to one-third of the paired paraventricular nuclei innervate the neurohypophysis.

2. The presence of pars distalis is not essential to a marked diabetes insipidus lasting many months, but is essential to its permanent maximum maintenance through trophic effects on thyroid and adrenal cortex.

3. Moderate diabetes insipidus may exist in the presence of the pars distalis when the residuum of functional neurohypophysis is sufficient to prevent any increase in urine output in the absence of the pars distalis.

4. When sufficient exogenous thyroid and desoxycorticosterone are administered simultaneously to produce a marked increase in urine output of the totally hypophysectomized diabetes insipidus dog, the additional administration of anterior lobe extract decreases the urine output.

5. Thyroidectomy immediately terminates the transitory polyuria of simple hypophysectomy. It will not eliminate but may depress somewhat the polyuria of the totally hypophysectomized dog (complete absence of all divisions of the hypophysis).

It has been shown that in the dog the denervation of the neural hypophysis results in a loss of basophil cells in the glandular hypophysis leaving only eosinophil and chromophobe cells. A lesion in the posterior hypothlamus so placed as to sever fibers rostral to the paired paraventricular nucleus, from the thalamus and subthalamus, results in a considerable decrease in number of hypophyseal basophil cells and in the density of granulation of those remaining. In such dogs obesity develops, but not diabetes insipidus.

The eosinophil cells have been shown by us to be trophic to the adrenal glands, to the corpus luteum, to the androgenic cells and to the renal tubule cells. Their overaction can account for many of the signs and symptoms associated with Cushing's syndrome

and with lesions in the region of the pineal gland. Evidence for an endocrine function of the paneal has not been established.

As a result of these observations, we can account for the obesity associated with pinealomata as being due to the exaggerated action of the eosinophil cell and adrenal cortical hormones. We can account for excess growth and sex changes because the eosinophils secrete the growth and the androgenic hormones.

Dr. Byron Stookey, New York: Dr. Horrax is to be congratulated on presenting an interesting clinical problem. He calls attention to the fact that pinealomas may extend into the third ventricle and forward so as to involve the hypothalamic region, where they can produce diabetes insipidus. These tumors are occasionally extremely soft and may extend even into the fourth ventricle and forward to surround the optic chiasm, as was illustrated by a patient whom I had operated upon some five years ago, the patient doing well until recently when he began to show signs of bitemporal hemianopsia. This clinical sign was difficult to explain on the basis of a posteriorly placed pineal neoplasm. At autopsy it was found that the tumor had extended forward so as to implicate the optic chiasm. I remember a similar patient of Dr. Tilney's in which the tumor had extended not only forward along the base but also posteriorly into the posterior fossa. The growth was soft and extensive in character. Thus, these tumors may be discrete tumors and calcified or, if they take on more rapid growth, may by extension invade the anterior cranial fossa as well as the posterior cranial fossa.

Dr. Horrax was too modest to refer to his earlier work, of which he was among the first to describe the ocular signs associated with pinealomas, which are almost diagnostic of them.

Dr. John Martin, Chicago: In 1939 I had the opportunity to review, with Dr. Louise Eisenhart, the case histories of 18 patients with pineal tumor in the Cushing files. Many of these are familiar to Dr. Horrax. Among these, eight patients had diabetes insipidus, but these eight patients had not been studied specifically for any implantations of tumor in the hypophyseal region and, in some cases, destruction of the third ventricle was so great it would have been difficult to determine the exact cause of the diabetes. At the same time we were running experiments in our laboratory on dogs, cats, rats and monkeys to determine the effect of the destruction of the pineal gland in immature animals. Destruction of the pineal gland was carried out by means of the Horsley-Clark stereotaxic apparatus which gave a discrete lesion without damage to any of the surrounding structures. While we found evidence of change in our animals in both somatic and sexual development we did not have any instance of diabetes insipidus in our entire series. Neither did we find any destruction of the neural pathways leading from the pineal gland and region thereof or any other changes in the third ventricle or brain stem. We did note an increase in the eosinophilic cells in the male animals. Dr. Horrax's studies are in keeping with the work done earlier in our laboratory when the paraventricular nuclei were destroyed by electrolytic lesions in cats, following which the pancreas was totally removed. Such animals did not develop diabetes.

Dr. Francis C. Grant, Philadelphia: Dr. Horrax has outlined the situation with regard to the treatment of tumors in the pineal recess and the posterior part of the third ventricle in his usual thorough manner. It is certain that many of the tumors in this area respond readily and in a definitive fashion to x-ray treatment. It is my experience that they are very difficult to handle from an operative standpoint. If these tumors can be attacked by any method short of direct surgery, it is a great advantage insofar as the patient is concerned. In the past ten years we have had 13 cases in which the tumor was located in the posterior part of the third ventricle. In this group there have been seven deaths resulting directly from operative intervention. In three cases both an attempt at surgical removal and subsequent x-ray treatment were ineffective and the

patient succumbed within a year. Three cases have survived ten, seven, and six years. In two cases, surviving for ten and seven years, operative removal was obviously incomplete. X-ray therapy was instituted. In these cases, partially calcified prior to attempted extirpation and x-ray therapy, not only has the patient remained symptom-free but the calcification within the walls of the tumor has definitely increased. In the third case, presenting a minimal calcification preoperatively, all the calcified area, at least, was removed during the surgical attack, although the operative note states that the extirpation of the tumor is probably incomplete. In this case the patient has remained well and subsequent intensive x-ray treatment has produced no further calcification. In each of these three surviving cases and in the three cases that were attacked surgically, but who did not survive the operative procedure and x-ray therapy for more than a year, a large decompression was always afforded at the base of the bone flap. A decompression in these cases is valuable, in our opinion, for two reasons. Primarily, it helps carry the patient through his early postoperative course when edema is sure to follow the operative trauma. Secondly, it permits expansion of the ventricle locally so that, if a secondary attack on the tumor seems indicated, an enlarged ventricle will be found and the approach to the tumor through the ventricle may be made with greater ease. I have a very definite impression that, in these tumors in the pineal recess and the posterior part of the third ventricle, decompression, plus x-ray therapy, will in the long run, possibly, show more satisfactory results than a direct attempt surgically to remove these deeply seated and inaccessible lesions.

Dr. Howard C. Naffziger, San Francisco: It has been our experience also that a considerable percentage of pineal tumors are responsive to x-ray therapy. The immediate danger, as stated, is from reactionary swelling of the tumor with complete obstruction of the aqueduct, and the consequent dangers of intracranial pressure. It seems, however, that the precautionary subtemporal decompression recommended by Dr. Horrax should not pass without comment. It does not relieve the obstruction, and will not do more than provide a very temporary and probably inadequate relief for fluctuations in the amount of intraventricular fluid. As a protection, it seems logical and I believe it is advisable to provide for ventricular puncture or temporary continued drainage of the fluid extracranially until the danger is past.

Dr. Gilbert Horrax, Boston (closing): I want to thank all the discussors very heartily. In regard to Dr. Martin's comment, I am familiar with the work he and Dr. Davis did in connection with the Brain Tumor Registry. I did not mention it, but it appears in the bibliography of the paper. So far as Dr. Grant's discussion is concerned, I did not mean to imply that every tumor in the posterior portion of the third ventricle would respond to this treatment. Some tumors, however, do respond, and we thought some less severe measure than exploration should be done to see if this would be so.

The question Dr. Naffziger brings up is a very interesting one. I realize that what he says is theoretically true. You cannot expect permanent relief from subtemporal decompression in lesions which block the aqueduct. I can recall, however, in the old days before ventriculography was available, when we were dealing with unlocalized tumors, we would do a subtemporal decompression. The patients would be improved sometimes, even though later it turned out to be a subtentorial tumor which blocked the aqueduct. The two patients who had decompression and went through x-ray treatment did very well. In the third, we did not do a decompression and he had a severe upset during the course of treatment, doubtless due to blocking of the aqueduct of Sylvus. Just what decompression does we do not know, but apparently it lets fluid get through temporarily at least, so patients do not have upsets during treatment. So far as the catheter is concerned, that is left in for a matter of only 24 or 48 hours at most, attached to a sterile bag. That is done in all our cases now, but it was not in during the time of x-ray treatment.

THE TREATMENT OF FOCAL EPILEPSY BY CORTICAL EXCISION*

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FOCAL EPILEPTIC DISCHARGE can now be localized in all areas of the cerebral cortex. Excision of partially damaged convolutions adjacent to meningocerebral scars or in areas or brain atrophy has proved to be effective treatment. This is demonstrated in the series of cases about to be reported. Attention will be focused upon surgical technic and the elements in these cases that seem to promise success or failure.

A. LITERATURE

Attempts to stop epileptic seizures by making a hole in the skull doubtless began in the era of prehistoric trepanation. Surgeons began to carry out craniotomies for this purpose in the early nineteenth century with no other therapeutic plan than to open and look. Nevertheless, the published reports of this period are surprisingly optimistic.† Once antisepsis and asepsis had opened the flood gates of surgery, there appeared extravagant claims of "cures" of epilepsy by many types of operation, from craniotomy to sympathectomy and resection of the large bowel. However, in the face of critical analysis, this optimistic phase passed and today, except for the removal of brain tumors, the role of surgery in the treatment of the epilepsies has become small indeed in most clinics.

Sir Victor Horsley was the pioneer in the application of physiologic principles to the problem, and it is interesting that his first three craniotomies (1886) were undertaken for the cure of focal epilepsy. One patient had a meningocerebral scar, one a tuberculoma, and the third a post-traumatic cyst. Two years later, Keen (see Ballance, 1922) published three somewhat similar cases. However, eventual surgical opinion of the results of such a procedure is well expressed by a Philadelphia surgeon, Nancrede. After reporting success in 1888 and 1892 he wrote (1896) in a sadder and wiser vein that surgical excision could be considered no more than a palliative procedure because the surgeon left behind him a new scar in the place of the original lesion.

* Read before the Meeting of the American Surgical Association, March 25–27, 1947, Hot Springs, Va.

† For example, see Wells (1812), Dudley (1828), Baron Larrey (1829), Heyman (1831), Astley Cooper (1839). Billings (1861) collected 62 reports of which 42 were called "cures"!

Gerster and Sachs (1892), also Horne (1894), cast the same gloom upon this form of surgical therapy. Hadra (1894) emphasized the desirability of reproducing the patient's own seizure by electrical stimulation as well as the motor responses. Woolsey (1896) used an osteoplastic bone flap in his excision of the lesion in six cases, but had only one "cure." Krause (1912) reported that he had carried out cortical excisions in 54 patients, of whom he considered four cured, but his follow-up was quite inadequate. He did state that the Kocher "valve" or decompression operation gave inadequate results in 34 cases.

Cushing (1908) reported 59 cases of epilepsy treated surgically, but he carried out "extirpation" in only 13 and included examples of brain tumor together with birth trauma and head trauma, so that it is not possible to estimate the elements responsible for the fact that 12 patients seem to have been made seizure free.

Excisions of localized areas of brain have been reported more recently in relatively small groups of cases by Little (1922), Foerster and Penfield (1930), Rowe and Watts (1936), Furlow (1938), German (1939), Voris (1943), with a varying incidence of "cures" and near-cures.

Penfield and Erickson (1941) published a complete analysis of all patients who had cortical excision carried out during a ten year period, 1929-1939. There were 115 patients who were thus followed from one to 11 years, with the result that 43 per cent were seizure free or had had one or two attacks, 26 per cent considered themselves 50 per cent improved, 9 per cent were slightly helped, and 22 per cent not improved.

B. PATHOLOGIC NOTE

A variety of lesions may give rise to cerebral seizures, but there is no reason to call the patients epileptics in the common understanding of the term nor to suggest taint of inheritance. A brief reference may be made to the pathology of certain epileptogenic lesions.* Brain lesions of many types are apt to produce some local destruction of nerve cells. After such destruction, neuronal regeneration does not occur in the central nervous system. But, unless all circulation to the part is destroyed, the neuroglia react in a positive way, producing gliosis. Destructive processes are also associated with phagocytosis of myelin and other material. The end result of these changes is gross atrophy of the involved convolutions.

Meningocerebral cicatrix. When trauma or infection has involved a local area of the brain, there results an intermingling of connective tissue and neuroglial tissue which eventually produces a contracting scar. A connection is thus established between the cerebral vessels and the extracerebral vascular tree through the scar. Ganglion cells disappear at the center of the damaged area and at the periphery they are subjected to abnormal conditions.

* For further discussions see—Penfield (1927), Penfield and Humphreys (1940), Evans and McEachern (1937), Penfield and Erickson (1941), chapter IX.

Local cortical atrophy. Compression and ischemia are capable of producing atrophy within the convolutions of the brain without the entrance of connective tissue into the scar, but with the appearance of a local glial overgrowth and the disappearance of ganglion cells in the zone of greatest involvement.

Local microgyria. At the time of birth it seems likely that the following sequence of events occurs. One, or a group of, gyri may be injured and partly destroyed by ischemia or by local compression during the period of the passage of the head through the birth canal. During the subsequent year of life, the normal portions of the brain grow very rapidly, each gyrus crowding outward and pushing the skull before it. The injured gyri do not grow, but are crowded in together. The important thing, however, is that they do not disappear. The total number of ganglion cells is greatly reduced within them, and the remaining cells are subjected to abnormal influences.

Expanding lesions. Brain tumor or cerebral abscess as it expands destroys the ganglion cells and white matter. At the periphery of such lesions is found a zone in which the ganglion cells of the gray matter are able to survive but are subjected to abnormal influences similar to those about other lesions; that is, the blood supply to these ganglion cells is reduced to a critical level.

Cysts and other abnormalities may be the result of a congenital defect or of vascular occlusion. Complete interruption of circulation in a region results in a cyst. But at the periphery there may be found partially normal ganglion cells in atrophic gyri. If, on the other hand, the interference with circulation is only partial, only an area in which the gyri are atrophic results without central cyst formation.

This brings us to a realization of the fact that all of these factors which may produce epileptic seizures have a common feature, which is illustrated in Figure 1. This feature is the presence of a zone or area of ganglion cells, the circulation of which has been interfered with to such an extent that its continued life is threatened. It is at some point in these peripheral or partially destroyed zones that the actual focus is to be found, the focus in which the epileptic discharge originates. Histologic study of such areas indicates that there is a continuing variation in circulation which results in occasional, spotty destruction of ganglion cells even years after the original injury or compression.

Thus, it may be assumed that partial anoxemia, if not sufficient to destroy, produces in ganglion cells an abnormal state, a supernormal state in which spontaneous neuronal activity is increased. This increase may be called the *epileptogenic factor.*

It seems obvious that no neuronal discharge can originate in a cyst or tumor or scar that is devoid of nerve cells. It also seems obvious that if surgical therapy is to be effective it is not sufficient to cut adhesions or to open a cyst, or in some cases to remove a tumor. The epileptogenic focus in the marginal partly-involved gyri must also be removed, and, furthermore, it seems obvious that in this removal any gyrus that is involved should, where feasible,

be excised wholly, leaving the neighboring gyrus covered with its own blanket of pial blood vessels.

C. ANALYSIS OF RESULTS

The patients included in this review of the results of radical surgical therapy of atrophic epileptogenic lesions of the brain were operated upon in the six year period 1939-44. Because this was the war period, when urgent problems took priority, many such patients were sent away without operation. The time of follow-up varies from one to seven years. All operations were carried out, or supervised, by W. P.; the follow-up analysis was made by H. S.

A total of 76 patients was operated on for epilepsy. Every one of the 76 has been followed up to the time of writing. Six of these had a second operation for further removal of epileptogenic tissue, making a grand total of 82 operations. There were 50 males and 26 females. Only one patient died as a result of the operation, his death being caused by an infected extradural hematoma and meningitis. The case mortality was thus 1.3 per cent, and the operative mortality was 1.2 per cent. Of the 75 cases to be followed, cortical excision was performed in 59 and craniotomy without excision in 16.

The results were determined as follows: a seizure must involve movement before it was counted as such; auras, without subsequent movement or loss of consciousness, were not counted as a seizure in the statistical analysis. All results were counted from the time the patient was discharged from the hospital.

The grouping* of results is as follows: 0 = failure, 1 = 25 per cent improvement, 2 = 50 per cent improvement, 3 = 75 per cent improvement, 4 = 100 per cent improvement. The patient was asked in each instance to express his own conclusions in these percentages. Many who had gone for years with one, two or three seizures considered themselves completely cured, but such individuals were placed in Group 3. Those in Group 4 have had no attacks since leaving hospital.

Expressed in another way, Groups 4 and 3 are satisfactory. The result was a success. Group 2 includes the fair results and 1 and 0 are poor. Routinely, no medication was given following operation except phenobarbital, and that usually for a year or two in decreasing amounts. All patients had had thorough, prolonged treatment by various medications before resort to operation.

Of the 59 patients (Table I) who had a cortical excision, there were 15, or 25.3 per cent, who were completely free of seizures. The number and length of time they have been free is: 7 years—1; 6 years—2; 5 years—3; 4 years—2; 3 years—2; 2 years—3; and 1 year—2. Eighteen, or 30.5 per cent, were almost completely free and were placed in Group 3. Thus, a total

* This method is borrowed from the system employed by the Presbyterian Hospital, New York, where the follow-up system has reached a high degree of efficiency under the direction of Professors Allen Whipple and Walter Palmer.

of 33 patients, or 55.8 per cent of the total, were free of attacks or had had only one or two, and considered themselves 100 per cent cured or almost so. Eight, or 13.6 per cent, were in Group 2. Adding Groups 2, 3 and 4 together, we find that there were 41, or 69.4 per cent, who had sufficient relief to make the procedure well worth-while. Seven patients, or 12 per cent, were only slightly improved, Group 1, while 11 more, or 18.6 per cent, felt that they derived no benefit from the operation and were therefore put in Group 0.

1. *Meningocerebral Scar Compared with Atrophic Cerebral Lesion.* The nature of the simple cerebral lesion varied. Sometimes it consisted in simple

TABLE I

RESULT OF OPERATION

Operation	Groups 4	3	2	1	0	Total Cases
Cortical excision.....	15 25.3%	18 30.5% 55.8%	8 13.6%	7 12%	11 18.6%	59
Craniotomy without excision.....	0	0	5 32%	2 14%	9 54%	16

convolutional atrophy. Occasionally there was little gross evidence of abnormality. There were 31 meningocerebral cicatrices and 28 cerebral lesions which were excised. In the former group there were nine patients, or 29 per cent, who were completely free as against six, or 21 per cent, with cerebral lesions. However in Group 3, nine patients, or 29 per cent, with meningocerebral cicatrix were "almost cured," while nine patients, or 32 per cent, were in the same group of cerebral lesions. If Groups 3 and 4 are combined, then 58 per cent of the meningocerebral cicatrices had a satisfactory result as against 53 per cent of the cerebral lesions, giving a slightly higher score of 5 per cent for the former.

2. *First Seizure After Operation.* What are the chances of having a satisfactory result from operation if a seizure occurs within a few months of discharge from the hospital?

In the group of 16 craniotomies without excision (Table I), 14, or 86 per cent, began to have attacks in the first six months, while the remaining two had return of seizures in the second six months. In the cases where craniotomy was associated with excision, 18, or 30.6 per cent, had poor results (Groups 1 and 0). All of these patients had a speedy return of attacks within the first six months.

In Group 2, the first seizure occurred as follows: during the first six months after operation—4 patients, or 50 per cent; 7 to 12 months—1; 13 to 24 months—2; and 25 to 60 months—1.

In Group 3, the first or the only attack occurred as follows: during the first six months after operation—5, or 28 per cent; 7 to 12 months—5, or 28 per cent; 13 to 24 months—7, or 39 per cent; 25 to 60 months—1, or 5 per cent.

3. *Results According to Cause of Lesion.* The initial cause of the lesion responsible for the attacks in each case was studied before and during operation. In many this was quite clear, but in some it was indefinite. If the cause was obscure, it was labelled "unknown."

TABLE II

PROBABLE CAUSE OF CEREBRAL LESIONS

	Birth Injury	Head Injury	Infection	Unknown	Total
Cortical excision.....	17	26	9	7	59
	29%	44%	15%	12%	
Exploration only.....	3	3	0	10	16
	19%	19%	0	62%	

TABLE III

RELATIONSHIP OF SURGICAL THERAPY TO CAUSE

	Groups					Total
Cause	4	3 (4+3)	2	1	0	Cases
Birth injury.....	7	6	1	1	2	17
	41%	35% (76%)	6%	6%	12%	
Head injury.....	5	8	4	4	5	26
	19%	32% (51%)	15%	15%	19%	
Infectious process.....	1	4	2	1	1	9
	11%	45% (56%)	22%	11%	11%	
Unknown.....	2	0	1	1	3	7
	29%	0 (29%)	14%	14%	43%	

Injuries that obviously dated back to birth comprised 29 per cent of the excision group, as shown in Table II. Of these, 16 per cent (Table III) had a satisfactory result, with 41 per cent in Group 4 and 35 in Group 3. Gross head trauma accounted for 44 per cent of the excision cases (Table II), and of these 51 per cent had a good result (Table III). Infectious processes, such as healed brain abscess, meningitis and cortical thrombophlebitis, comprised 15 per cent, and 56 per cent of these had a satisfactory outcome. In only 12 per cent of the patients was the initial cause unknown; of these 29 per cent had a satisfactory result.

4. *Interval Between Brain Injury and Onset of Seizures.* The histories of all 75 patients were studied to determine the length of time between production of the lesion and onset of the seizures. The analysis yielded the following figures:

Birth injury. —None had an onset of seizures in the first year, while 18 per cent started having them in the two to five year interval. Thirty-five per

cent began in six to ten years, and 47 per cent in 11 to 20 years. Thus, 82 per cent had their first seizure after the age of five years.

Head injury.—If the injury was due to head trauma after birth, 38 per cent began to have seizures in the first year after the accident, 50 per cent in the two to five year interval, 8 per cent—six to ten years, and 4 per cent—11 to 20 years. Thus, 88 per cent of these patients had onset of attacks within the first five years.

Infection.—Only nine patients could have the cause of epilepsy traced to an infectious process, such as brain abscess, meningitis and cortical thrombophlebitis. However, 56 per cent of them had an attack within the first year, and 22 per cent in each of the two to five and six to ten year intervals. Thus, 78 per cent began having seizures within the first five years.

To summarize this portion of the analysis—Cause was assigned in 52 per cent of the 75 cases. The attacks began within the first year after the brain damage in 31 per cent of the cases. They began during the next four years in 33 per cent, and in the subsequent 15 years in 36 per cent of the cases. The longest free interval before onset of seizures tends to occur in the cases of birth injury.

5. *Relationship of Duration of Seizures to Outcome of Operation.* In Table IV, the patients were grouped according to the period of time of operation after the onset of the attacks. Reference to the table indicates that the duration of the seizures has little or no effect upon the outcome of treatment by excision. It indicates also that the establishment of so-called "epileptic habit" is of no importance if the proper excision is carried out.

6. *Relationship of Aura to Result of Excision.* The patient's aura or warning that an attack is imminent is the most valuable single localizing sign. The 59 patients in whom an excision was done were grouped according to their various auras to see if any prognostic indications could be discovered.

No aura. Nineteen patients had no aura at all; either they lost consciousness at the outset or movement began without previous warning. Ten of these, or 53 per cent, had a good result following operation.

Somatosensory aura. Twenty-four patients had a sensation in some part of the body before convulsive movements began; this sensation was variously described as numbness, tingling, pain, pressure or fullness. Fifty-four per cent had a successful result.

Viscerosensory aura. Five patients had a visceral warning. Two of these had an epigastric sensation which ascended to the chin before consciousness was lost. One had a feeling of nausea, one epigastric pain, and one a unilateral body aura. Four of the five have had a satisfactory relief from seizures.

Visual aura. Six patients were warned of an attack by visual sensations of lights or spots before their eyes. Half of them had a satisfactory operative result.

Dreamy state aura. Two had an illusion of perception or an hallucination in advance of convulsive movements. One had a good result.

Auditory-vertiginous aura. One patient had an aura of dizziness and buzzing; she was not helped.

Forced thinking. Two patients had an aura of thoughts which came to them and which they could not suppress. Both of them have had good results.

7. *Relationship of Site of Excision to Result.* The cerebral excisions were grouped according to the area in which the excision was made, to determine what difference in outcome there might be. Of course, many of the removals involved more than one lobe and in these the site of the major removal was taken as the group into which it fell. The number of patients and the percentages of satisfactory results are as follows: frontal pole—14 cases, 71 per cent satisfactory; midline frontal lobe—three, 0 per cent; central region—16, 69 per cent; temporal lobe—14, 50 per cent; parietal lobe—five, 40 per cent; occipital lobe—seven, 43 per cent. The differences are not very significant, but the frontal pole and the central areas have a higher scoring.

8. *Relationship of Pneumoencephalogram to Result of Excision.* Pneumoencephalograms were made in 54 of the 59 patients. In 78 per cent of these there was some degree of localized ventricular deformity which suggested an atrophic lesion. Of those with such a deformity, 58 per cent had a satisfactory result. Of the 22 per cent whose pneumoencephalogram was of no localizing value, only 42 per cent had a satisfactory result.

An encephalogram was made in 15 of the 16 patients who had no cortical excision carried out. Eleven, or 73 per cent, of these showed local atrophy; none of the patients were listed in the success groups.

9. *Physical and Neurologic Examination.* In 41 per cent of the patients, the physical and neurologic examination, exclusive of local injury or deformity of the skull, pointed to a local lesion. Of this group, 67 per cent were in Groups 3 or 4. Of the 59 per cent whose examination did not localize a lesion, 49 per cent had a good result from operation.

10. *Preoperative Electroencephalography.* All of the patients had a preoperative electroencephalogram taken. The method of recording has been described by Jasper elsewhere (see pp. 380 to 455 in Penfield and Erickson, 1941). The preoperative electroencephalogram of each patient was classified in the manner described by Jasper and Penfield (1943).

The preoperative electrographic conclusions are tabulated in Table V for the 16 cases in which no excision was made at craniotomy and also for the 59 cases with excision. This table does not include electrocorticography* after exposure of the brain. It may be pointed out that a superficial cortical focus is apt to give rise to potential changes of brief duration and high voltage that are recorded in the electroencephalogram as "spikes." A similar focus somewhat deeper, *i.e.*, in the gray matter at the bottom of a fissure or on the under surface of a lobe, appears in the scalp electrogram as a somewhat slower

* An estimate of the value of this procedure will be made in a subsequent report.

alteration in potential called a "sharp wave." The delta waves referred to in Table V indicate brain injury either due to an advancing process or as the temporary result of severe seizures.

When clinical studies indicate that there is a localized focus giving rise to periodic seizures, the electroencephalogram may be carried our repeatedly and hyperventilation, hydration or metrazol used to increase the activity of the focus until the source is mapped out. Some sort of electrographic localization was thus worked out in all but three cases, and in two cases the electroencephalographic abnormality was unclassified. In none of these cases was the result satisfactory.

TABLE IV

RELATIONSHIP OF SURGICAL THERAPY TO PREOPERATIVE DURATION OF SEIZURES

Years Before Operation	Total Patients	Success Groups 3+4
1	3 – 5%	1 – 33%
2–5	25 – 43%	14 – 56%
6–10	16 – 27%	10 – 62%
11–20	9 – 15%	5 – 55%
21–30	6 – 10%	3 – 50%
	59	33 – 56%

TABLE V

PREOPERATIVE ELECTROENCEPHALOGRAMS

E.E.G.	Negative Explorations	Success Groups 3+4	Excisions	Success Groups 3+4
Spike and/or sharp wave focus	4	0	21	11 – 52%
Same with contralateral transmission	5	0	16	14 – 88%
Same with bilateral synchronies	4	0	9	4 – 44%
Same with delta elsewhere	0	0	9	3 – 33%
Same with other foci	0	0	2	1
No focus	3	0	0	0
Unclassified	0	0	2	0

It is of interest that when the electroencephalogram indicated a localized discharge with secondary conduction of the abnormal waves to the opposite side, the prognosis for a good result with excision was excellent, 88 per cent. But it is to be observed that in five such cases the surgeon was unable to decide what area to remove, probably because of the lack of gross abnormality.

Electroencephalography in the hands of an experienced interpreter prevents the surgeon from operating upon patients who suffer from idiopathic epilepsy. The finding of a three per second dysrhythmia typical of "petit mal epilepsy" is a contraindication to operation. More rapid bitemporal dysrhythmia may prove, on analysis, to be due to a unilateral lesion deep in one temporal lobe.

Only one patient operated upon had an electroencephalogram which was classified as not of epileptic pattern. This patient had choreoathetosis with focal seizures. Her electroencephalogram showed an increased amplitude

of beta rhythm over the central area on the right side. Removal of the arm area did not stop her seizures but cured the involuntary movements. Recent electroencephalograms in this case have suggested a deep temporal lobe focus for the seizures.

11. *Postoperative Electroencephalography.* Postoperative electroencephalograms were taken in the case of 56 out of the 59 patients after their cortical excisions. This was done in the third or fourth week following operation and after the withdrawal of phenobarbital for 48 hours. Further records were made months or years after operation on some of the patients, but these are too few to be of statistical value and are not included in this report.

The postoperative electroencephalograms taken thus before leaving hospital are tabulated in Table VI. The criteria of improvement, as established by

TABLE VI

POSTOPERATIVE ELECTROENCEPHALOGRAMS AND PROGNOSIS

Postoperative E.E.G.	Patients	Success Groups 3+4
A. Normal	11	9 – 82%
B. Much improved	16	16 – 100%
C. Slightly improved	9	3 – 33%
D. Unimproved	11	2 – 18%
E. Severe delta	9	2 – 22%

Doctor Jasper, were diminution in amount and amplitude of sharp waves, spikes and rhythmic slow waves. A normal record indicates no sharp waves nor spikes. Minimal random slow waves are not considered abnormal in the first few weeks postoperatively.

If the first group—A—and the second group—B—in Table VI are taken together, there are 27 cases in which the postoperative electroencephalogram gave a normal or much improved record, and 25 of these patients had a successful result of operation. On the contrary, little or no immediate improvement in the postoperative electroencephalogram gives small promise of a good result. In retrospect, it seems likely that further excision should have been considered in some of these cases before discharge.

12. *Postoperative Complications.* Various postoperative complications to which the neurosurgeon may "fall heir" are summarized in Table VII. Of the patients who had cortical excision, 14, or 25 per cent, had one or more convalescent seizures while in hospital. Of these, five, or 36 per cent, had a Group 3 or 4 result, but only one of them was in Group 4 with complete freedom from attacks. In the control group (not included in Table III) where no excision was made, ten patients, or 71 per cent, had postoperative attacks during convalescence, and none of these had a satisfactory outcome.

Six patients had a second operation for further removal of epileptogenic tissue. One of these had a satisfactory result, and two of them a perfect result.

13. *Medication.* Before operation, the best known forms of conservative medication and treatment were given a fair trial. In every case this included

phenobarbital and almost always dilantin. After operation, phenobarbital was given in most cases for a year or more, and if a seizure occurred, it was continued indefinitely. Of the 15 patients who have been completely free of seizures, eight are taking no medication whatsoever, and the remainder take anti-convulsant drugs irregularly as a precaution. Of the 18 who are in Group 3, all but one are taking phenobarbital regularly.

14. *Economic Results.* All but one of the 33 patients in the success Groups 3 and 4 are working or studying full time; he has a paralysis of one arm and will be able to work when he learns a trade. Two require supervision because of occasional behavior difficulty. Among those with better results are two physicians, six university students, one school teacher, two stenographers and one professional musician. Even in Group 2 with only a 50 per cent improvement, it is possible for some patients to be economically self-supporting.

TABLE VII

POSTOPERATIVE COMPLICATIONS AND PROGNOSIS

Complication	Excision Cases	Success Groups 3+4
Convalescent seizures	14	5 – 36%
Reoperations further excision	6	3 – 50%
Reoperations for bleeding	3	2 – 66%
Aseptic meningitis	5	4 – 80%

15. *Analysis of Failures.* There were 18 patients, or 30.6 per cent, who were not helped appreciably by cortical excision. At operation the removal was considered satisfactory in only three. In the other 15 the lesion was too diffuse for complete removal, or else complete removal would have probably resulted in paralysis or aphasia and thus rendered the patient worse after operation than before.

The 16 patients of the control group, who were operated upon but for whom no cortical excision was deemed advisable, are also to be considered failures. In three, a subtemporal decompression was carried out; in three, lysis of adhesions; in one, removal of a calcified subpial mass; and in one, removal of a calcified subdural hematoma. The diagnoses in this group were: hyperostosis frontalis interna, two; craniostenosis, one; arteriovenous aneurysm, one; focal atrophy of brain, three; calcified subpial mass, one; calcified subdural hematoma, one; and no objective lesion, seven.

Postoperative electroencephalograms were taken in 15 of the 16. In none of these was there any appreciable electrographic improvement, and none of these patients could be placed in result Groups 3 or 4, although two felt that they had been helped as much as 50 per cent and were therefore placed in Group 2. Two patients were helped as much as 50 per cent and one slightly improved. Thus, 13 out of 16 were not helped at all. This would seem to indicate that craniotomy which does not include removal of abnormally functioning cortex has no chance of success.

D. CASE STUDY

Patients who suffer from epileptic seizures can be studied by means of a simple classification. As information accumulates, it may be necessary to shift the individual from tentative classification under one heading to final classification under another (Table VIII).

1. *Classification.* **a. Idiopathic Epilepsy.** In this class the electroencephalogram shows a bilateral disturbance in brain potentials of characteristic form. The seizure begins with loss of consciousness, and when small is of the type recognizable as "absence" or "petit mal." There is often an epileptic tendency in the families of such patients. For idiopathic epilepsy there is no effective surgical therapy.

TABLE VIII

WORKING CLASSIFICATION

A. Idiopathic epilepsy
B. Cerebral seizures
   Cause .....
C. Focal cerebral seizures
   Localization .....
   Cause .....

b. Cerebral Seizures. When the attacks are not clearly of the above type, the cause should be sought and the pattern of attack studied. If the cause proves to be due to hypoglycemia, to a degenerative condition of the brain, systemic disease, etc., surgical therapy is likewise not indicated, and the diagnosis is expressed, for example, as cerebral seizures, cause—hypoglycemia.

c. Focal Cerebral Seizures When the beginning of the seizures is clearly identified and if the cause is obviously not hereditary, metabolic, degenerative or neoplastic, then the diagnosis of focal cerebral seizures may be made. If conservative treatment does not control the attacks, then surgery may be given due consideration. In most cases the patient should be hospitalized for study so that the suitable cases may be selected.

2. *Attack Pattern.* Almost all patients have minor as well as major seizures. The nature of this minor attack or of the earliest beginning of the major seizure gives the observers a clue as to the site of origin. If this is a visual phenomenon, the epileptogenic focus is in the occipital lobe; if it is Jacksonian motor, it is in the precentral gyrus; if sensory, it is postcentral; if hallucinatory, it is temporal; if it begins with unconscious turning, it is one frontal pole, etc. (See Selected Writings of J. Hughlings Jackson, 1931; Penfield and Erickson, 1941.)

3. *Roentgenography.* Asymmetry of the skull or cranial hemiatrophy may be strongly suggestive of birth injury. Cranial defects or depressions and intracranial calcifications may, of course, be highly significant.

4. *Pneumoencephalography.* Ventricular study usually shows some evidence of local cerebral atrophy. That portion of the ventricle must be clearly

visualized which lies under the area of cortex incriminated by the seizure pattern.

5. *Electroencephalography.* Special methods of electrographic study make it possible to identify the location of epileptogenic discharge in a very high

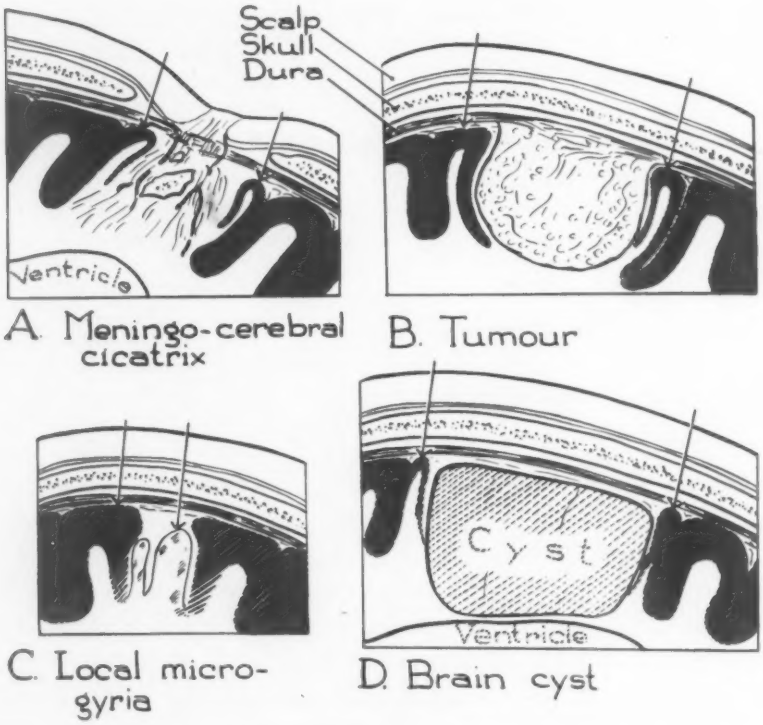

FIG. 1.—Schematic cross sections of lesions apt to produce foci of epilepotogenic discharge in the cerebral cortex. The arrows point to frontier portions of gray matter in A, B and D in which the convolution is partially destroyed. Such gray matter is apt to become the source of seizures, not all around, but only on one side of the lesion. In C, small gyri are shown containing a reduced number of ganglion cells. Such gyri result from local ischemia at birth (from Penfield, W. Chapter in British Surgical Practice, London, Butterworth, 1947).

proportion of cases of focal epilepsy (Jasper and Penfield, 1943). It is sometimes necessary to make repeated trials and to increase the activity of the focus by artificial means, such as hydration, hyperventilation, metrazol. (See Cure, Rasmussen and Jasper, 1947.)

A large area of brain may be abnormal and yet the discharging focus be present in only one small area. The electroencephalogram may thus be the surgeon's best guide. For example, in the case of T. K. there was a large traumatic lesion of the right frontal lobe. The electrographic record showed the presence of spike discharges, as illustrated in Figure 2, when the electrodes were placed on this portion of the scalp. Three weeks after radical

operative excision, the spike disturbances had disappeared and the record was nearly normal (Fig. 3). This patient has had no further seizures after seven years.

On the other hand, following brain damage, and also following brain operations, an unfavorable electroencephalogram may continue for years in the

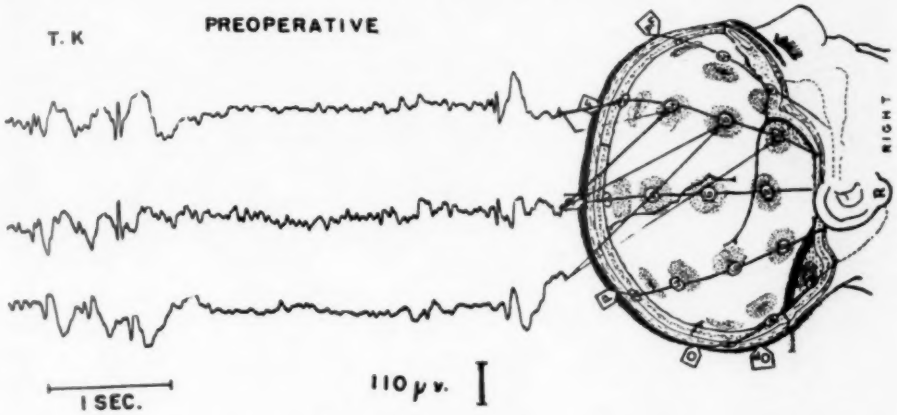

FIG. 2.—Case T. K. Electroencephalogram from scalp leads F2, 4, 6 and 8. The "spike" waves indicate a superficial epileptogenic focus.

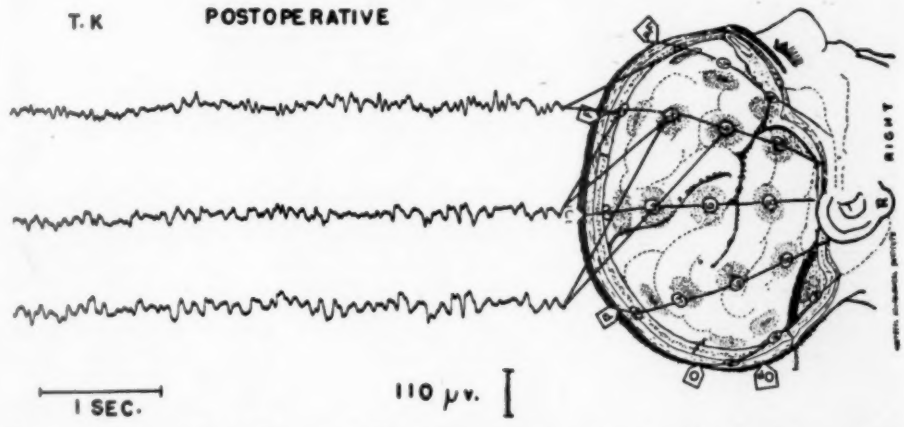

FIG. 3.—Same case as in Figure 2. Electroencephalogram from scalp leads PF2 and F2, 4 and 6 after removal of cerebral scar. The "spike" forms have disappeared.

absence of seizures. Therefore, the electrographic report alone does not justify surgical interference. Furthermore, the electroencephalographer can not predict with certainty whether injured brain will eventually develop into an epileptogenic focus.

E. OPERATION

No preoperative sedative is used and nothing more than codeine during operation. An osteoplastic craniotomy of adequate size is made under local

analgesia (Fig. 4). The dura is opened with great care so as not to injure the pia mater. If very dense adhesions are present, it is well to be sure that only that portion of brain is exposed which is likely to be removed. An electrographic study carried out upon the unopened dura is often a help in such a case.

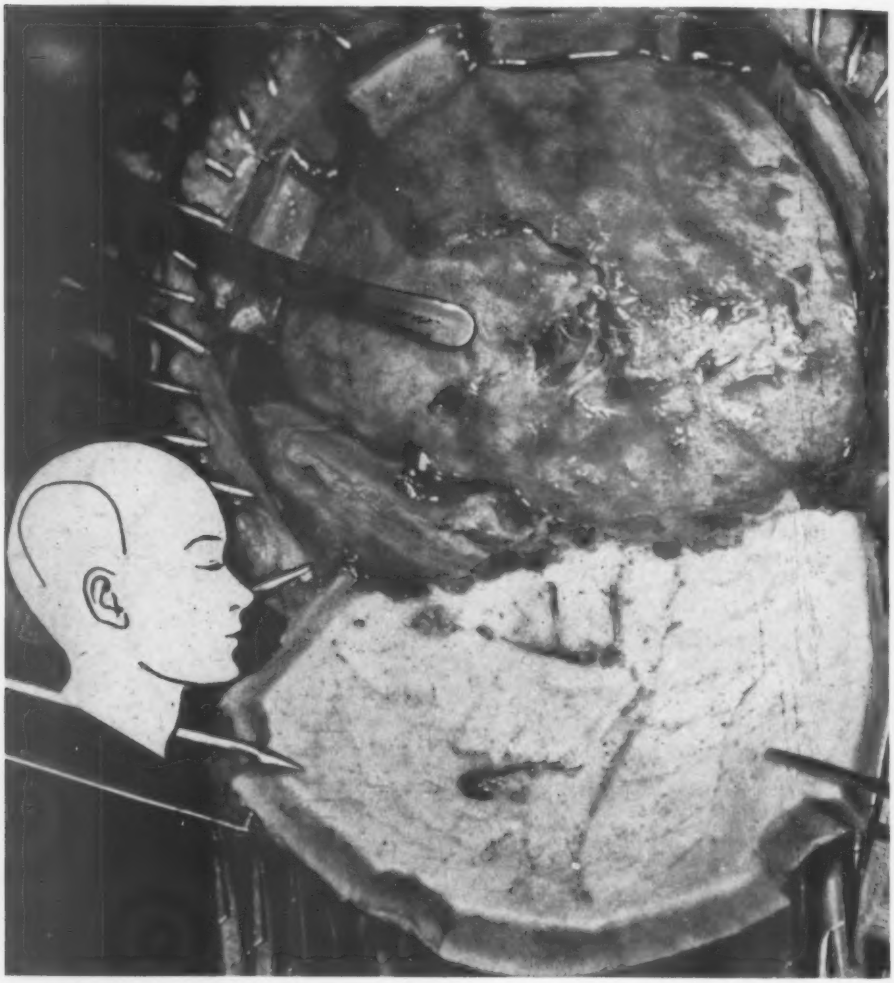

FIG. 4.—Case R. E. Craniotomy. Note line of fracture in the parietal bone, also the defects in the dura corresponding to erosions in the under surface of the bone flap. Exposed brain regularly produces such absorption of overlying skull.

When the brain is exposed the surgeon faces the problem of what area should be removed. He must bear in mind that the actual focus is usually a partly destroyed or atrophied gyrus still capable of function, however abnormal. As a preliminary, he should discover where the motor gyrus is by stimulation. He may try to induce the patient's aura or minor seizure by stimulation.

In the case of R. E. (Fig. 5) the point of maximum injury produced in the

cortex by the depressed bone fragment was obvious. Some study was required to discover how wide the excision could be without producing paralysis and how wide it needed to be in order to ensure relief of seizures.

Electrical stimulation of the cortex was therefore carried out, care being

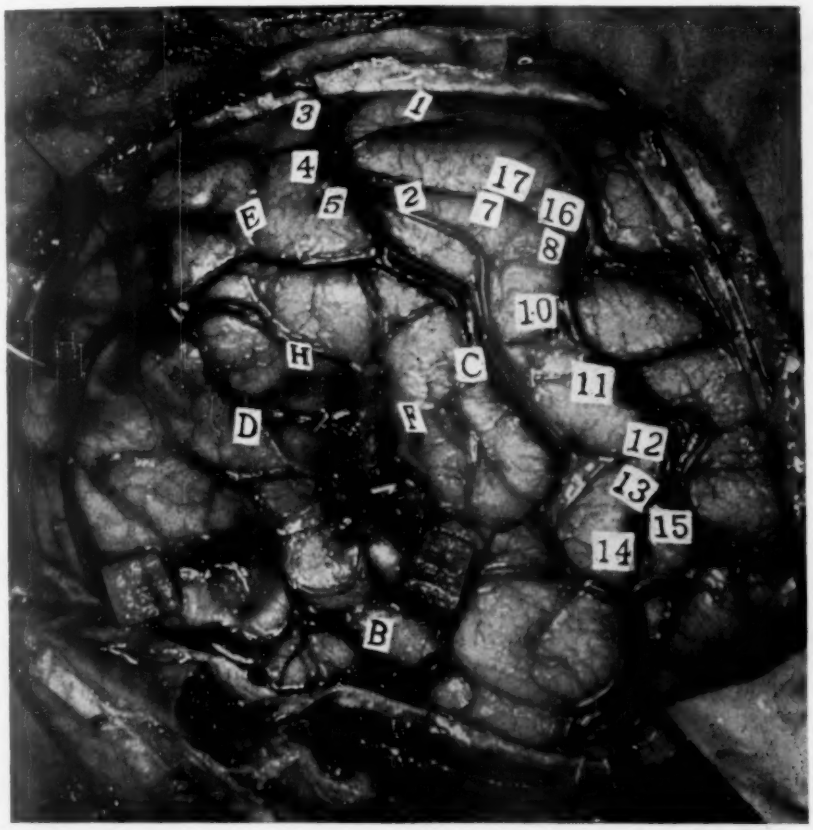

FIG. 5.—Case R. E. Brain exposed. Numbers on paper tickets mark points from which motor or sensory responses were produced by stimulation. Letters indicate points at which cortical electrographic recording showed "spike" activity. A black thread has been placed on fissure lines up to which excision of convolutions was proposed.

taken to avoid production of a motor (physiologic) seizure. A Rahm stimulator* is useful for this purpose, frequency 60 per second, beginning with ½

* This stimulator was modified by Rahm after the original model described by Rahm and Scarff (1943). The modifications were outlined by Dr. Herbert Jasper and the electrical characteristics are as follows: It is a thyratron circuit providing a saw tooth wave form at frequencies of 1, 3, 8, 15, 30, 60, 90, and 120 pulses per second. The pulse duration is increased with a decrease in frequency of repetition to a maximum duration of 50 milliseconds at the lower frequencies. Stimulus intensities between 0 and 11 volts (peak) are read directly from a meter placed across the stimulating electrodes. A low output impedance permits considerable variation in resistance between the electrodes with minimal changes in stimulating voltage.

volt and increasing to one or two volts. The patient will report sensation from stimulation of the postcentral gyrus or movements may be produced by stimulation of the precentral gyrus. There is no other way of being sure where the central fissure is. In Figure 5 small paper tickets have been placed on points where stimulation produced responses. For example: 1 = movement of left shoulder, 4 = pins and needles sensation in left shoulder, 5 = sensation in left hand, 13 = sensation in left side of tongue, etc. The position of the central fissure was therefore clear.

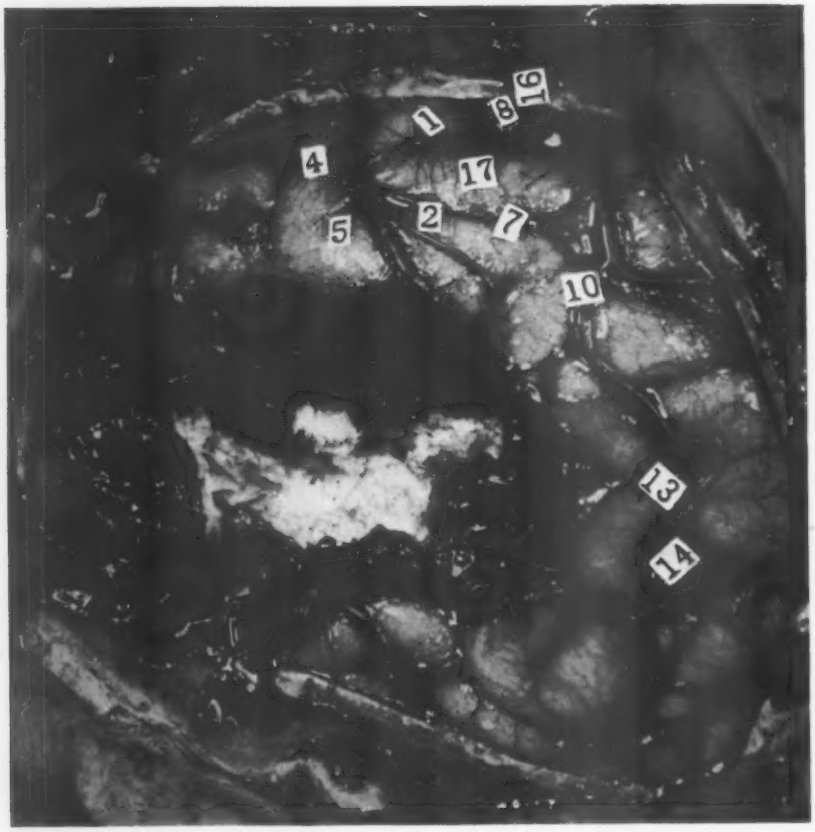

FIG. 6.—Case R. E. After the excision. Note that the remaining gyri are still covered with pia mater and pial vessels.

An electrocorticogram was carried out, placing electrodes directly on the brain. This showed a good deal of active "spike" discharge about the center of the lesion at B, C, D, F and H. It was decided, therefore, to make a wide excision along fissure lines, and a black thread was placed on the brain as a reminder of the proposed extent of removal. A circular incision was then made inside this line in the convolution between the thread and the central area injury. This incision was made by passing sutures through the pia mater and

then cutting the convolution by tying the suture. The central area was then taken out by undercutting with a dissector. This left behind a half centimeter of convolution about the area of excision. This remaining portion of the convolution was then removed subpially by means of a small sucker in such a way as to leave untouched the pia mater that covered the adjacent gyri. The result is shown in Figure 6.

During the removal, the patient may be examined to determine whether function has been altered. At the end of the removal he is allowed to go to sleep with the aid of avertin or pentothal.* The dura is closed, the bone flap replaced and fastened with steel wire. A drain is often placed in the extradural or subdural space and brought out through a small separate incision in the scalp to be removed after 24 hours.

By this technic it is possible to remove all gray matter that has lost its pia in so far as this is possible. It leaves the white matter exposed at the base of the excision. An effort is made not to open the ventricle but to leave ependyma intact. An open ventricle in such cases is apt to produce postoperative fever (aseptic meningitis).

Large excisions may present special difficulties. In the case of D. G., the right occipital lobe was largely destroyed by a subdural hematoma and cerebral compression at birth. When the lobe was exposed at operation (Fig. 7), subdural adhesions were cut and a zone of electroencephalographic "spike" activity was demonstrated, as shown by letters A, B, C, D, and E. The whole lobe was then amputated, leaving a fairly well preserved convolutional frontier. It was not possible to spare the ependyma. Consequently, the ventricle and choroid plexus are seen to be exposed.

The postoperative course was stormy. The wound was reopened to evacuate an extradural hematoma. This was followed in turn by a scalp infection which was treated and then closed secondarily. A prolonged period of aseptic meningitis followed. Nevertheless, healing was eventually satisfactory and the boy has been free of seizures during the two and one-half years since operation, and certain behavior difficulties have disappeared along with the seizures, an added benefit which is not uncommon.

F. EXCISION TECHNIC

Horsley (1909) first described the subpial method of convolutional removal, and Sachs (1935) and Furlow (1938) endorsed it. Foerster (Foerster and Penfield, 1930) used the method of cutting with a thread, the line of excision being made down the middle of each convolution as far as possible, thus leaving half of the convolution. Penfield used the same method for the 115 patients operated upon in the 1929 to 1939 period (Penfield and Erickson, 1941).

* Dr. Ronald Stephen (our associate in charge of anesthesia) finds that avertin tends to drop the pressure too much at the close of operation. He prefers sodium pentothal intravenously, combined with a 50-50 mixture of nitrous oxide and oxygen administered through a nasopharyngeal tube, using a non-rebreathing valve. Most patients required an intravenous saline infusion, some a transfusion.

In the present report the removal method is a modification of the two, the central area being excised by the thread method and the peripheral zone being cleaned out subpially by suction. The results in this series are 12 per cent better than in the earlier series, but that does not necessarily demonstrate that the improvement is due to the altered technic of removal.

More accurate indication of the success of excision technic may be found in the postoperative electrogram. In 19 of the excision cases (17 per cent), the electrogram gave evidence that remaining gray matter had been damaged at

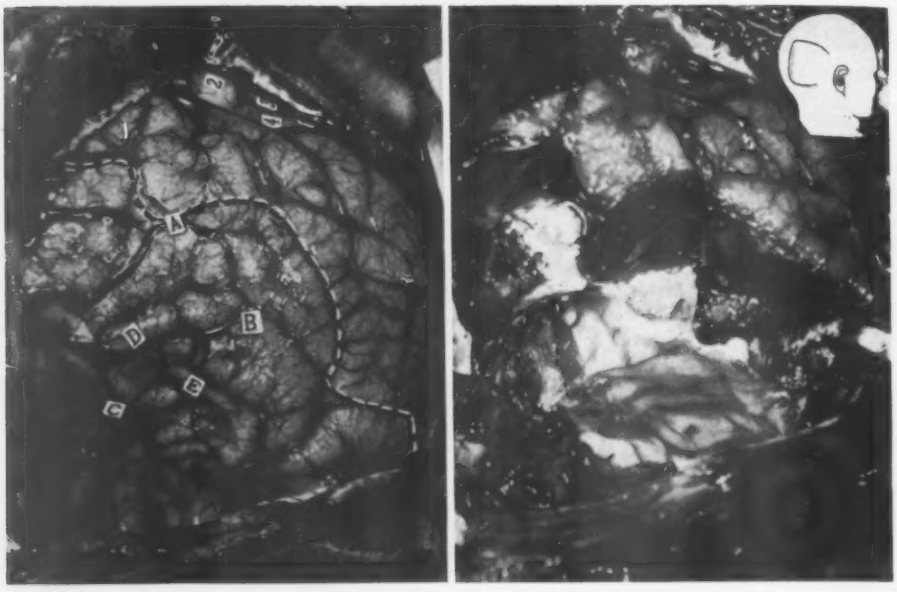

FIG. 7.—Case D. G. On the left is shown the occipital lobe injured at birth. A, B, C, D, and E indicate electrographic evidence of epileptogenic activity. Numbers 2, 3, and 4 lie on the postcentral gyrus, as proved by stimulation. The broken line indicates the limit of proposed removal. On the right the removal has been carried out, consisting in an occipital lobectomy. The ventricle, unfortunately, had to be opened.

operation or that it had had its circulation interfered with. This was indicated by the presence of large slow waves (delta waves). Only two of these patients, or 22 per cent, had a satisfactory result. The conclusion seems to be that for these 19 patients there was either some imperfection in the execution of the technic or that a better technic should be devised so that no delta waves appear after operation. When a surgeon is able to pass the test of the postoperative electrogram, he may claim that his technic of excision is satisfactory.

G. SUMMARY AND CONCLUSION

There is a large group of patients ordinarily treated on a symptomatic basis as essential epileptics. Some simple working classification, such as that in Table VIII, should be used to distinguish these sufferers from those that are

subject to cerebral seizures due to systemic abnormality or to idiopathic epilepsy. In the differential diagnosis of such patients the terms "grand mal" and "psychomotor epilepsy" are confusing unless it is recognized that they refer to electroencephalographic patterns with no particular clinical significance.

In this present series of 76 patients, there was one death (1.2 per cent operative mortality). Of the 59 patients who had excision, 15 had no further attacks during a one to seven year postoperative period (Group 4), and 18 had one or two seizures but considered themselves cured or practically so (Group 3). Adding the two groups together, 56 per cent of the patients had a successful operation. Sixteen similar craniotomies were carried out without excision and none of these was successful (Table I). It therefore seems fair to conclude that epileptic seizures, due to cerebral abnormality, are not helped by craniotomy unless radical excision is carried out. Removal of adhesions, decompression, or closure of cranial defects have no effect upon the attacks unless the proper excision is carried out.*

The elements of success or failure in the excision series are to be sought in an analysis of the nature of the lesion, the methods of study, and the technic of removal.

The cause of the original lesion in this series was most often head injury, secondly, birth injury, and, thirdly, local infection. The cause was unknown in 12 per cent of the excisions and in 62 per cent of the negative explorations (Table II). The duration of attacks before operation had little or no influence on the outcome (Table IV).

It is interesting that when the cause was head injury or infection, the onset of seizures was early. The beginning of attacks in these cases came within five years in four out of five cases. On the other hand, when the cause was birth injury, the onset of seizures was longer delayed. The beginning of attacks came after the age of five in four out of five cases. It would seem, therefore, that during infancy and early childhood damaged brain is usually slower to develop the epileptogenic mechanism than later in life.

The best results from excision were obtained in the birth injury group (76 per cent). Infectious processes came next with 56 per cent success, and head injury third with 51 per cent (Table III). Excision is equally effective when applied to meningocerebral scars or to simple cerebral foci. Removals in the frontal pole were most successful (73 per cent), and the central (or sensorimotor) cortex came next (67 per cent).

When attacks recur after operation and after the patient leaves hospital, the earlier they appear the more gloomy is the prognosis of eventual recovery. When attacks occur in the convalescent period while the patient is still in hospital, the prognosis of a good result is extremely poor if the pattern of onset is the same as before operation. Attacks that indicate a neighboring gyrus is subject to edema or anoxemia will have a different pattern and may produce less

* When craniotomy without excision results in cessation of attacks, it is likely that the patient should have been classified in the idiopathic group. Such patients occasionally have spontaneous cessation of seizures.

pessimism. If the pattern is the same as preoperatively, an immediate second operation should be considered. Six patients were thus subjected to a second excision, and three of them were thus placed in success groups (Table VII).

As the result of this present analysis we would conclude that the persistence of a "spike" electrographic focus after operation or the appearance of marked "delta" electrographic activity near the site or removal should cause the surgeon to consider reoperation (Table VI).

In preoperative studies, the simpler the electrographic record is and the better it is localized, the better the prognosis of a successful excision. The more diffuse the electrographic abnormality, the less hopeful is the prognosis (Table V). It must be added, however, that a well localized, simple electroencephalogram, not supported by pneumographic or other evidence of a lesion, has sometimes led us to a useless exploration, i.e., a craniotomy without excision. Excision guided solely by electrographic abnormality seems to be a procedure of doubtful value. The uses of electroencephalography during operation (electrocorticography) are still being studied and will be reported upon at a later time.

In conclusion, the surest guide to localization of an epileptogenic zone is the seizure pattern. The greatest supplementary help a surgeon can receive is electrographic study by an expert,* and it is fair to say that this special method of study has opened a new chapter in the treatment of focal epilepsy. However, the electrogram without objective change in the cortex and without the other means of study is not yet to be trusted as the final guide to excision.

Radical excision seems to offer a reasonable possibility of cure (56 per cent) to those who have cortical foci of discharge and whose attacks are not controlled by medication. All patients operated upon within a given period have been included in this report, so that the elements of success and failure may become apparent and in the hope that this may prepare the way for future advance.

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* We must express our gratitude to Dr. Herbert Jasper, and to his pupil in electroencephalography, Dr. John Kershman, for guidance and stimulation in the study of this series.

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DISCUSSION.—DR. GILBERT HORRAX, Boston: I think we all owe a great debt of gratitude to Dr. Penfield for the work he has done for a long time on the surgical treatment of epilepsy. This is such a widespread disorder that any type of treatment that offers relief is most important. I think the things for neurosurgeons to remember are these: First, careful neurologic study preoperatively so far as history and type of seizure are concerned; second, we ought to have the help of men like Dr. Jasper for electroencephalographic interpretation and, third, that the epileptic focus does not confine itself to the area seen at operation but may extend beyond the area, and this should be studied for response to electric stimuli.

DR. W. J. MIXTER, Boston: This is a very important contribution. Dr. Penfield's work we all know, he having had more experience than any of the rest of us in this type of work, and his results are probably better than most of us can have. This comes with particular importance at this time, because we have a large number of post-war epileptics in the world today, many of whom are open to treatment along these lines. When we consider the number in this country and multiply that by the number there must be in backward countries where there are no means of handling these cases, we can see the load the world must carry in caring for these cases.

One thing seems to me of great importance. That is the study of encephalography on the open brain which Dr. Penfield alluded to. I believe this is a very important part of the operation, and I want to stress that fact, because there have been too many of these scars excised without testing the cortex. As Dr. Horrax said, many of these show extension of the epileptic focus to the side away from the scar, and in such cases simple removal of the scar itself will not cure the patient. I would like to hear what is being done in the Veterans Administration concerning this group of cases.

DR. W. MCK. CRAIG, Rochester, Minn.: Dr. Mixter has referred to the Veterans Bureau and epilepsy. Realizing that subsequent to all the head injuries sustained in the last war there would be a large number of post-traumatic epilepsy cases; the National Research Council has endeavored to set up committees and subcommittees to supervise projects in the Veterans Hospitals. Follow-up studies are to be carried out and when epilepsy occurs these cases are to be dealt with in a manner similar to that described by Dr. Penfield.

By his work Dr. Penfield will prove a great benefactor to the veterans program and merits our gratitude for his efforts.

DR. WILDER PENFIELD, Montreal (closing): I am very glad that Dr. Horrax emphasized the importance of electroencephalography. It is the greatest aid, although the study of the simple epileptic patterns still remains the most important method of localizing attacks. So far as electroencephalographic records from the exposed brain are concerned, we have been doing this for six or seven years but are not ready to make final judgment as to its value. It does help, but it is possible, also, that it may misdirect the surgeon because of the altered condition of the cortex after exposure.

Dr. Mixter called attention to the great body of post-traumatic cases from the war, the world around. During the next five or ten years there will be an enormous number of veterans complaining of post-traumatic epilepsy. The attacks are apt to begin any time in the ten years following injury. I feel that in Russia the incidence may be higher than here because of their different technic in handling brain wounds. They left the brain wound open for a longer period than was the habit here. That remains to be seen.

Dr. Craig mentioned the work with veterans. Our feeling in general is that the veteran who has seizures should be treated for at least a year by all possible conservative measures before operation is considered. The duration of seizures has no influence upon the eventual result of operation. There may be an epileptic habit, but if the focus is properly removed the nerve pattern of habit goes with it.

URGENT SURGERY IN THE AGED*

CONDICT W. CUTLER, JR., M.D.

NEW YORK, N. Y.

LITTLE AS THE SURGEON may relish major operative procedures on patients in the seventh decade or beyond, there occur occasions when he is forced to intervene to preserve life. With the consistent aging of the population, such occasions may be expected to occur with ever greater frequency.

The Goldwater Memorial Hospital of New York, serving the chronic patients drawn from all the City's hospitals and from the City Home for aged and indigent persons, has furnished opportunity for the observation of surgical emergencies in old people. This review is based on the experiences of the Second Surgical Division over a period of seven years.

The 204 patients who were the basis of these observations ranged in age from 60 to 102. The average age of the group was 74. These patients presented not only the "normal" deteriorations of age, but also many of the diseases of senility in chronic and advanced form.

These factors of deterioration and of disease give the problem of urgent surgery in the older age group its special character. When an emergency arises, there is little opportunity to improve the patient's physical status and none to rectify fundamental organic defects. Frequently encountered in our patients were myocardial degeneration, valvular heart disease, overweight, malnutrition, the results of previous coronary infarction or cerebral vascular accident, tuberculosis, lues, diabetes, anemia, vitamin deficiency states, hypoproteinemia, arterial sclerosis, varieties of renal or hepatic dysfunction, or combinations of these defects.

These conditions often entailed difficulties of early and accurate diagnosis, since the defects might mask or mimic conditions requiring quick surgical intervention. There were also serious postoperative complications. These old patients are peculiarly susceptible to pneumonia, wound disruptions and sepsis. Many of them succumb, even weeks after operation, to cerebral-vascular accidents, to coronary occlusions, uremia, anuria, and cardio-vascular-renal collapse. While the mortality rate attending urgent surgery in this group was high (84 deaths following 188 operations, or 44 per cent), the survivals represent surgical salvage of individuals who, unaided, would almost surely have succumbed. Our attitude was well expressed by Rowntree[1]: "All would agree that every effort should be made to save life in acute emergencies, unless the patient is already in extremis." Of our 204 patients presenting surgical emergencies, 15 were either in extremis or refused surgery, and all 15 succumbed.

Certain general principles of therapy were adopted to meet the requirements of this class of case: (1) Utilize every quickly available measure for support

* Read before the American Surgical Association, March 26, 1947, Hot Springs, Va.

and protection. (2) Undertake the remedial operation with the least possible delay. (3) With a minimum of trauma and in the shortest feasible time, perform the simplest procedure that will relieve the emergency. (4) Employ every means to safeguard the patient against postoperative complications and watch diligently for signs of their development.

In carrying out the principle of support and protection in the preoperative period, we have tried to take advantage, as they became available, of all valuable measures: replacement of depleted fluids and electrolytes, correcting impending acidosis with glucose and insulin, furnishing new blood or plasma, using the hydrolysates to raise the lowered blood protein level, employing concentrated vitamin solutions to promote tissue repair or to minimize hemorrhage, or the anticoagulants in thrombotic or embolic states. The antibiotics have proved a powerful ally, and the patient about to be submitted to operation, whether septic or not, should not be deprived of their protective and prophylactic effects. Penicillin has become our stand-by (although more than half of our patients were seen before it became available), and it has been our custom to begin its employment preoperatively in doses up to 100,000 units at three hour intervals. We have found it important in these elderly patients to recognize the inability of the failing heart and kidneys to deal with large quantities of fluids if given rapidly by vein.

While the value of the principles enunciated by Ravdin[2] and by Whipple[3] concerning replacement of weight loss, high caloric diet and the increased administration of food proteins as preoperative safeguards was recognized, time was lacking in these urgent cases to carry them out. In our own experience, as in Bailey's,[4] all too often serious ailments were permitted to develop well beyond the margin of safety before surgical opinion was consulted.

Supportive measures should not delay unduly the performance of urgent surgery where early intervention is required. These old people deteriorate rapidly under sepsis, death of tissue, or obstruction of the intestinal tract. Delays in laboratory or X-ray investigations, in ineffective efforts at intestinal intubation or in trying to reach an unattainable optimum in the patient's condition may lead to failure.

The choice of appropriate anesthetic is important. Depressant or toxic anesthetics are unusually hazardous in the aged. We have veered away from spinal anesthesia, apprehending the circulatory depression that frequently attends its use. The fear of respiratory depression has deterred us from the barbiturates. Chloroform and vinethene have too marked toxic properties, while nitrous oxide anesthesia involves anoxia. Cyclopropane proved an almost ideal anesthetic, combining low toxicity, rapid induction and recovery and good relaxation, and permitting high oxygenation. Ether we found reliable, reasonably safe, and effective. Latterly, intocostrin has served to increase relaxation, permitting the use of smaller quantities of cyclopropane or ether. We have seen no ill effects from its use.

Local anesthesia was useful in many cases, but if it produced toxic effects, prolonged the operative procedure or failed to allay shock-producing pain, it

was inappropriate. Since large doses of morphine as a basic sedative are not well tolerated, we have supplemented smaller doses (gr. 1/8) with small amounts of scopolamine (gr. 1/150) with satisfactory results. In some cases we have combined scopolamine with demerol (50 mg.) with equally good effect. Refrigeration anesthesia for amputations, as proposed by Crossman[5] and Allen,[6] became almost routine after the middle of 1941.

With skilful use of the anesthetics now available, the anesthesia has not constituted a grave risk. In the 188 operations recorded, there was only one fatality in which the anesthesia was involved. Pneumonia, following operation, occurred in about the same relative frequency with each of the types of anesthesia employed, and in roughly half of the cases, appeared ten days or more after the anesthetic.

Our experience parallels that of other observers. Bancroft[7] prefers local or cyclopropane anesthesia. Knight and Baird[8] like local or block anesthesia, but have not been satisfied with them in abdominal operations. Forestiere,[9] anesthetist at the Goldwater Memorial Hospital, states: "Results with inhalation anesthesia are not surpassed by those with local, regional or other anesthetic procedures." Rowntree[1] observes that old people take anesthetics well. Quigley[10] found that the type of anesthesia had little or no effect on mortality. Rankin[11] sums up the matter: "A good anesthetist, a short operative time and careful postoperative care will render the use of general anesthesia in old people as safe as any other anesthetic available."

Minimum trauma at the operation is nowhere so important as in the poor-risk elderly patient where shock must be avoided. The surgeon learns that he must be both accurate and fast, although as Rowntree[1] puts it, "Better an hour or more of gentle manipulation than five minutes of clumsy bungling."

The emergency operation on the old patient should be the least and simplest procedure that will meet the issue. Once the emergency is passed, the patient may be prepared under far more favorable circumstances to undergo any additional operation required. Elective resections and anastomoses, meticulous repair of hernias, prolonged exploration of the common bile duct and plastic amputations have no proper place in emergency surgery on old people. As Rankin says,[11] "The nicety of surgical judgment as to when, what and how much to do is the keynote to success in these patients." During the course of the emergency operation, continuing support and protection of the patient are important. Most valuable, as Wangensteen[12] suggests, is the replacement of all blood lost by administration of blood, or at least by plasma.

During the early postoperative hours, shock has been our first concern. Our chief reliance in combatting it has been in the use of blood and oxygen. It has been our practice to continue oxygen for at least six hours after operation, and for several days in some instances. Stimulant drugs have been, in the main, disappointing. Postoperative sedation must be cautiously managed.

To prevent atelectasis, thorough aeration of the patient has been regularly performed at the close of the operation and during the succeeding 24 hours, rebreathing procedures carried out. Nurses were instructed to move and turn

the patients frequently, to assure that a free air-way was maintained and that no aspiration of vomitus occurred. These measures, plus the continuance of penicillin, are the best insurance also against pneumonia. The termination of bed rest at the earliest possible moment has been our policy since the start of our service. This practice no doubt has had value in preventing phlebo-thrombosis and decubitus. In our patients who were out of bed early we encountered no instance of wound dehiscence. This accident occurred more frequently in patients who of necessity remained bedridden and was the product of distention, sepsis, wound infection, vitamin deficiency, lowered blood protein or the presence of carcinoma, rather than of the muscular action produced by early rising.

Closely spaced through-and-through retention sutures in abdominal closure seemed to provide the best safeguard against disruption, supplementing careful repair by layers, special attention being given to accurate closure of the peritoneum. Special effort was made to provide optimum nutriment and to correct anemia, metabolic disturbances and deficiency states.

Fortunately phlebo-thrombosis has been rare. Our present policy is to ligate and divide the superficial femoral vein of the leg showing involvement. If cryptogenic embolization occurs, we rely on heparin plus dicumarol.

Attention to moving, keeping the patient dry (for many of them were incontinent), early ambulation, avoidance of pressure and maintenance of nutrition sometimes failed to prevent decubitus. When ulcers occurred, we were unable to reproduce in these old patients the brilliant results of plastic closure or grafting that we saw in the young victims of decubitus during the war.

A factor in the recovery of the old person who has undergone urgent surgery is the will to live. Rankin[11] emphasizes the bad effects of "regimentation and the domination of a relentless and impersonal routine." Lacking encouragement or an alert and sympathetic interest in their complaints, having no incentive and no outlook to a less miserable future, sick old people are prone to lapse into a state of unresponsive indifference and lethargy from which a terminal pneumonia usually provides the ultimate release.

The general principles above outlined may be illustrated by citing the more common surgical emergencies we encountered.

AMPUTATIONS

The emergency most frequently met was gangrene of the lower extremity, associated with arterio-sclerotic occlusion, with or without diabetes. Usually there was premonitory complaint of pain in the extremity and evidence of diminished arterial circulation. The onset of the complete occlusion was heralded by increased severity of the pain, cyanotic pallor of the affected part, and coldness. We encountered no case of embolic occlusion in which it was feasible to attempt embolectomy.

The obvious death of one toe or more, or a part of the foot or leg, did not constitute an emergency. Conservative treatment awaiting demarcation was then in order. If spreading infection in the extremity became apparent with

elevation of temperature, rapid pulse and an ascending flush or lymphangitis, amputation became urgent. Local incision or amputation anywhere within the zone of active cellulitis served only to make a bad matter worse. A lower-third or mid-thigh amputation was the proper treatment, and the sooner employed the better.

Penicillin was administered in large doses, blood for transfusion procured, and the infected extremity segregated by tourniquet and local refrigeration begun. Crossman's[5] technic proved most effective and we rarely found it necessary to employ any other anesthesia. Following the application of tourniquet and ice, the patient's condition generally improved. This procedure put a stop to the spread of sepsis at once and gave three hours or more of refrigeration to devote to preparatory, corrective and supportive treatment. As a means of anesthesia the method in our hands was not superior to other anesthetics in the matter of operative risk or postoperative complications.

In septic cases, flap-forming procedures resulted often in septic and necrotic stumps and were abandoned in favor of the circular type of amputation. Loose closure of such stumps has been, until recently, our method, but a high incidence (60 per cent) of the breaking down of these wounds dictated the adoption of the completely open treatment with the application of skin traction, as advocated by Kirk for war injuries. With this method we have seen less suppuration and spreading infection in the stump. Applied with a plaster cuff and outrigger, such traction does not require bed confinement. One reason for the ineffectiveness of flaps and sutures has been demonstrated repeatedly at the operating table where, even at a generously high level, the main artery has been found completely obliterated by sclerosis and organized clot and the compensatory circulation so meager as to produce very little bleeding.

In patients suffering from diabetic gangrene there may, or may not, have been premonitory evidence of progressive peripheral circulatory failure. Invasive infection, with following cellulitis and gangrene gained access through an abrasion or dermatophytosis of the foot, from a closely cut corn or around an old horny toenail. Bringing the blood sugar under control in some instances served to localize the infection. Surgical treatment then was conservative. Where the infection was advancing, amputation was called for.

There were 73 cases of gangrene of the extremities. The average of these patients was 72 years. All showed evidence of arterial sclerosis, while 62 had clinical manifestations of arterio-sclerotic heart disease. Twenty-nine, or more than a third of them, had diabetes. Fulminating sepsis was present in 45. Fifteen were nephritic, 12 had had cerebral accidents and 17 suffered from coronary disease. Five had had previous leg amputations for gangrene. Among the other complications, which in most cases were multiple, were fractured femurs, leg ulcers, decubitis, active tuberculosis, anemia, prostatism, gastric ulcer, syphilis, rheumatic heart disease, bacterial endocarditis, pericarditis, cirrhosis, pneumonia and empyema, while one patient was recovering from an operation for acute intestinal obstruction.

Eight of the 73 either refused operation or were inoperable. All of these succumbed.

Incision and drainage of suppurating areas about the foot or the amputation of gangrenous toes was followed in 20 cases of the 65 by obligatory thigh amputation within a few days. We gained a distinct impression that it was often a precipitating factor.

Of the 65 operations performed, 59 were mid-thigh amputations, four were of the Carden type. One of these required subsequent mid-thigh amputation for sepsis. Two amputations were below the knee. One of these developed gas gangrene demanding a mid-thigh amputation four days later. Fifty-six operations were of the circular type, while three were done with flaps. Forty-six had light suturing of muscle and skin over the bone end and 30 of these stumps suppurated, two with gas infection. The skin alone was loosely sutured in 16 cases and broke down in six. Thus 60 per cent of the sutured stumps broke down, leading to the present tentative practice of leaving open stumps with skin traction in septic cases. This may prove to be too conservative, but thus far we have been pleased with their healing by granulation.

Other postoperative complications were: Pneumonia, 22; sepsis, 6; shock, 3.

For anethesia, cyclopropane was used in 20 cases, spinal in ten. Most of these were given prior to 1941, as was one nitrous-oxide-oxygen anesthesia. Since the introduction of refrigeration anesthesia, most of the amputations

TABLE I

GANGRENE OF EXTREMITY

Number: 73 Average Age: 72

Preoperative Condition	
Arteriosclerosis	73
A. S. H. D.	62
Diabetes	29
Sepsis	45
Nephritis	15
Cerebral accident	12
Coronary disease	17
Decubitus	12
Pneumonia	4
Tbc.	2
Lues	2
Fractured femur	4
Leg ulcers	5
Previous major amputation	5
Septic endocarditis	1
Pericarditis	1
Empyema	1
Acute intestinal obstruction	1
Cirrhosis	1
Gastric ulcer	1
Prostatism	7
Severe anemia	8

8 unoperated—all died.

Amputations, 65	
Thigh	59
Carden's (knee)	4
(1 reamp. for sepsis)	
Below knee	2
(1 reamp. p. 4 d.—gas)	
Circular (guillotine)	56
With flaps	3
Suture of muscle and skin	46
Broke down	30
(2 gas infections)	
Suture of skin only	16
Broke down	6

60% of sutured wounds opened

Anesthesia		
Cyclo	(Pn. 8—40%)	21
Spinal	(Pn. 3—30%)	11
Crymal*	(Pn. 9—30%)	31
N_2O	(Pn. 1)	1

* Supplemented with:
Vinethene (1)
Cyclo (1)
Pentothal (1)

No anesthetic accident.

Postoperative Complications	
Pneumonia	22
Sepsis	6
Shock	3
Recovered	40
Died	25
Mortality	38%
Day of death (av.)	11
Cause of death:	
Pneumonia	11
Sepsis	1
Shock	3
Decompensation of coronary	6
Cerebral accident	2
Bleeding gastric ulcer	1
Gangrene other leg	1

(31) have been done with it. There have been no anesthetic accidents. Pneumonitis occurred in 40 per cent of the cyclopropane cases, in 30 per cent of the crymal anesthesias, and in 30 per cent following spinal. Six of eleven fatal cases of pneumonia occurred ten days or more after the operation.

Of the 65 patients operated upon, 40 recovered and 25 died—a mortality rate of 38 per cent. The average day of death was the 11th. Three cases of shock died within 48 hours, the other victims at intervals up to one month. Pneumonia took the highest toll of 11 lives. Sepsis claimed one, cardiac decompensation and coronary accidents killed six, cerebral hemorrhage two, and bleeding gastric ulcer and gangrene of the other leg one each. The operated diabetic patients showed as good a recovery rate as did the non-diabetics.

INTESTINAL OBSTRUCTION

Among the causes were incarcerated and strangulated hernia, carcinoma of the large bowel, adhesions causing kinks or volvulus, foreign bodies, mesenteric thrombosis, and fecal impaction.

The diagnosis of intestinal obstruction in old people and the determination of its cause and location presented difficulties. Since many of them were chronically constipated, the absence of bowel movements for a day or two was likely to pass unnoticed. The complaint of some abdominal discomfort might easily escape attention, or the combination of the two situations might elicit an enema or a cathartic. These people not infrequently developed atonic colons loaded with fecal matter, often associated with massive rectal impaction, which produced a degree of intestinal obstruction. In such instances the enemas and cathartics usually relieved the situation.

Two or three days might pass after the onset of a true obstruction, particularly if it were in the large bowel, before the development of distention and vomiting led to the calling in of the surgeons. Our cases of obstruction were often well advanced by the time surgery could be employed. Faced then with an emergency, little time was permitted for investigation. We adopted the policy of instituting early surgical treatment for such patients as rapidly as the necessary replacement and supportive therapy could bring them to a state of operability. Dehydration and electrolyte deprivation were corrected, plasma given, and blood administered or procured. A digital rectal examination was done, and three-position X-ray films of the abdomen were made to detect fluid levels and identify the distended loops of gut. This was sometimes supplemented by a barium enema picture. Such studies often proved helpful in determining the most direct approach and the shortest procedure, obviating an extensive exploration. With the insertion of a tube into the stomach and suction decompression established, the patient was ready for operation.

(1) *Large intestine tumors.* In obstructive lesions of the large bowel, only cecostomy or colostomy was usually required. This might be done under local anesthesia. In performing a cecostomy through a right lower quadrant muscle-splitting incision, the withdrawal of a good segment of cecum through the skin was preferred. No opening was made in the gut until the wound had been

closed and protected. Then a tube of good size or Pessar catheter was inserted well into the intra-abdominal portion of the gut within a purse-string suture.

When a large bowel tumor was demonstrated at exploration through a rectus incision, this incision was closed and cecostomy performed. We learned the unwisdom of attempting to deal with the new growth itself, even by exteriorization, in the presence of acute obstruction.

(2) *Ileus of small intestine.* In obstructions of the small intestine, the symptoms were usually more lively in onset, leading to earlier recognition. Preoperative speculation proved fruitless in estimating the nature of the lesion. One might find a constricting band, kinks, volvuli, or internal hernia, with or without gangrene of the intestine, or even an obstructing foreign body. We were unable to differentiate before operation the cases of mesenteric thrombosis from those of mechanical ileus.

We found a generous incision to be a sound investment. Once found, the obstruction was relieved as rapidly and with as little handling as possible. When the gut was found to be definitely gangrenous, exteriorization of the affected loop gave the best chance of immediate survival, but involved the dangers resulting from intestinal fistula. When the lesion was in the jejunum or upper ileum, an anastomosis seemed obligatory. In the low ileum, exteriorization might be done with spur formation and later effort at restoration of continuity.

(3) *Hernia.* Incarceration or strangulation of intestine brought the occasional hernia into the field of urgent surgery. In cases of suspected obstruction, a small hernial sac might easily be overlooked. In the operation we preferred an abdominal approach if there was likelihood of gangrenous gut in a sac. Relief of the obstruction and adequate management of the gut was the primary purpose in such operation, and repair of the hernia, other than closure of the internal orifice, was not important. Release of the gut and protection of the peritoneum from spilling of intestinal contents was more surely to be accomplished by the abdominal route.

The postoperative care of patients recovering from intestinal obstruction consisted of suction through the stomach tube while distention or vomiting persisted, plus supportive and nutritive treatment. The patients were taken out of bed within the first 24 hours, or as soon thereafter as possible.

Of our 56 cases of intestinal obstruction, 52 were operated upon, while four were received in such condition that operation could not be undertaken. Twenty-four patients were operated upon within 24 hours of the onset of the symptoms, while others were not seen until two, three, four or five days after the beginning of obstruction. The average duration of symptoms was two days. These patients averaged 81 years of age. The oldest, who made a complete recovery, was 102. Forty-seven were markedly arterio-sclerotic and 37 showed gross clinical evidence of arterio-sclerotic heart disease. Seven had had cerebral accidents (one had suffered two), and five had previous coronary thrombosis. Nephritis, cirrhosis, pulmonary tuberculosis, paralysis agitans, central nervous system lues, crippling arthritis, prostatism, pyelo-nephritis, carcinoma

of the bladder, spinal cord tumor and recent amputation for arterio-sclerotic gangrene were some of the preoperative complications.

Twenty-three of the obstructions were due to strangulated hernias, 11 to cancer of the large bowel, nine to adhesions, five to volvulus, three to foreign bodies (one gall stone, one peach stone, one meat bone—perforated), one to lymphopathia venereum, while the causes of two were never determined.

Operation in 29 instances consisted in reduction of hernia, volvulus, or freeing of constricting bands. Four small intestine resections were done. There were 11 cecostomies, two colostomies and one ileostomy with exteriorization of loop. Cyclopropane was the anesthetic used in 22, local in 20, pentothal in two, ether in three, and spinal in five. There was but one anesthetic death, which occurred from aspiration of vomitus in one of the spinal cases. Spinal anesthesia was administered in some of our earlier cases but we are now opposed to its use in patients of this type.

The mortality was high. Twenty-three survived, while 29 died, giving a rate of 55 per cent. Pneumonitis was responsible for 13 deaths. Six succumbed to shock, six to cardiac failure, two to peritonitis. The patients dying of shock or cardiac decompensation succumbed usually within three days. Pneumonia killed as late as the 54th postoperative day. Other late deaths occurred from ruptured esophageal varices, cerebral accident and uremia.

TABLE II

INTESTINAL OBSTRUCTION

Number: 52 Average Age: 81

Preoperative Condition	
Arterio-sclerosis	47
Arterio-sclerotic Heart disease	37
Cerebral accident (One had 2)	7
Coronary thrombosis	5
Nephritis	12
Cirrhosis	1
Urological	
Prostatism	4
Pyelo-nephritis	2
Carcinoma of bladder	1
Lues	2
Decubitus	3
Arthritis (disabling)	4
Tuberculosis	2
Central Nervous System Disorders	
Paralysis agitans	4
Cord tumor	1
Lues (C N S)	1

Cause	
Hernia	23
Inguinal	11
Femoral	5
Incisional	2
Umbilical	5
Adhesions	9
Volvulus	5
Neoplasm of colon	11
Foreign body	3
(Gall stone 1)	
(Peach stone 1)	
(Meat bone 1)	
Lymphopathia	1
Undetermined	2

Duration	
Average	2 days
Less than 24 hours	24

Operation	
Reduction	29
Resection	4
Cecostomy	11
Colostomy	2
Ileostomy	1
Exploration	2
Enterotomy	3
(Removal of foreign bodies)	

Anesthesia	
Local	20
Cyclopropane	22
Pentothal	2
Ether	3
Spinal	5

Postoperative Complications	
Pneumonia	17
Peritonitis	2
Shock	7

Cause of Death	
Pneumonia	13
Shock	6
Peritonitis	2
Uremia	1
Cardiac failure	6
Cerebral accident	1
Aspirated vomitus (anesthetic accident—spinal)	1
Ruptured esophogeal varix	1

Result	
Recovered	23
Died	30
Rate	55%
Day of death (average)	4

The one best guide to prognosis was found to be the physical status of the patient at the time of his obstructive accident and the nature and degree of his pre-existing ailments. This observation corresponds with the conclusion of Brooks,[13] who noted that a high percentage of deaths in old people after operation occurred late and were due to pre-existing degenerative diseases.

APPENDICITIS

Acute appendicitis occurred only five times in 204 cases. (According to van Friedenfeldt[15] only 7.2 per cent of all appendicitis occurs in patients over 50.) Its behaviour was likely to be atypical, leading to difficulty in diagnosis. After a few hours of vague abdominal discomfort, without localizing signs, there might appear evidence of peritonitis and at operation a ruptured appendix be found. Or where a palpable right lower quadrant abscess was found, one might elicit the story of an episode of "indigestion" or "stomach ache" a number of days previously. In consequence, the diagnosis was often delayed. We noted, as did de Tarnowsky,[14] the vague nature of the onset and development of appendicitis in old patients, and the frequent and early occurrence of gangrene. We have felt it important to pay strict attention to the older patients' complaint of abdominal pain and to watch with care the blood count, the temperature, and particularly the pulse rate. The abdominal physical signs we have frequently found to be undependable or misleading.

For appendectomy we preferred the intermuscular right lower quadrant incision. Since the peritoneum in old people seems less capable of handling an infective insult than in the young, we have been guided by Blake's dictum: "When in doubt—drain," even with the help of the antibiotics. In localized abscess, incision and drainage, preferably with local anesthesia, seemed sufficient.

In seven years our staff operated on only eight patients on the diagnosis of acute appendicitis. The diagnosis was correct in four instances and wrong in four. One additional case, diagnosed as acute intestinal obstruction, proved to have a ruptured gangrenous appendicitis with peritonitis. Thus the diagnosis was accurate only four times in nine cases. Of the four cases incorrectly diagnosed as appendicitis, one had a massive perinephric abscess, one a perforated gangrenous diverticulitis of the sigmoid colon, one carcinoma of the cecum, perforated, with abscess, and one presumably a gastro-enteritis, since no pathology was found. The first two succumbed to sepsis. Of the latter two, one survived to die of already established metastases two months later and the other lived for three years, eventually to die of a cerebral-vascular accident.

Of the four cases correctly diagnosed and operated upon, three had already suffered perforation although their active symptoms were of but a day's duration or less. One patient with a four-day history of vague abdominal pain was found to have a well-developed abscess. This patient succumbed to peritonitis, as did the patient incorrectly diagnosed as intestinal obstruction. The other three survived. Mortality, 40 per cent.

TABLE III

ACUTE APPENDICITIS

Average Age: 71

Preoperative Condition	
Arterio-sclerosis	3
Diabetes	1
A. S. H. D.	2
Nephritis	1
Paralysis agitans	1
Symptoms	
Pain	4
Vomiting	3
Constipation	1
Fever	4
Average Duration of Symptoms	
Days	2

Diagnosis	
Correct	4
Incorrect	1
Operation	
Incision and drainage of abscess	2
Appendectomy	2
Incorrect diagnosis	1
Anesthesia	
Ether	1
Cyclopropane	2
Cyclopropane and local	1
Local and pentothal	1

Postoperative Complications	
Peritonitis	2
Shock	1
Cause of Death	
Peritonitis (1 day and 9 days)	2
Result	
Recovered	3
Died	2
Mortality rate	40%

ACUTE CHOLECYSTITIS

Infections and obstructions of the biliary tract presented some of the most difficult and dangerous problems found in the old age group. Of the patient of 70 or 80 with an acute cholecystitis or obstruction of the common duct, it may be assumed that cholecystitis has existed in chronic form for years and that the liver has suffered commensurate damage.

Our cases demanding urgent surgery for lesions of the biliary system numbered 34. Their average age was 73. Twenty-seven had advanced arterio-sclerosis, while 19 had symptomatic arterio-sclerotic heart disease. Fourteen suffered from nephritis, three had suffered cerebral accidents, and three had had coronary occlusions. Three manifested chronic pyelonephritis, while among the other or associated disabilities were central nervous system lues, miliary tuberculosis, amyotrophic lateral sclerosis, diabetes and paralysis agitans.

Quigley,[16] reporting on biliary disease in patients who averaged 69 years of age, noted that his ward patients presented poorer surgical risks than did his private patients. He ascribed this difference to poorer economic status and earlier deterioration in the former, as well as to delayed hospitalization. Of his 100 patients, five were operated upon for acute cholecystitis and one survived.

The cases in our group rapidly became profoundly ill with the onset of acute gallbladder inflammation or with the sudden occlusion of the common duct. More than once we have been puzzled to differentiate between acute cholecystitis or biliary colic and a coronary infarction. The patients' condition deteriorated so rapidly as the result of infection, pain and dehydration that delay in undertaking operation greatly enhanced the risk. Jaundice was not well tolerated.

Fifteen patients in this group manifested jaundice as a result of occlusion of the common duct, and six of them had concurrent cholecystitis. Common

duct exploration and drainage alone was performed in two cases, and common duct drainage with cholecystostomy in three. All succumbed. Cholecystostomy alone was done three times for obstructive jaundice, with one survival. Cholecystgastrostomy for obstructing cancer was performed twice, with one death and one early survival. Common duct drainage with cholecystectomy was done five times, twice successfully. Thus, 11 of 15 patients presenting obstruction of the common duct with rapidly advancing jaundice were lost. Hemorrhage was not a factor in this mortality due, it is believed, to liberal administration of vitamin K.

Acute cholecystitis without evidence of common duct obstruction also progressed rapidly. Seven of 19 such cases were found to have perforated, four of them within 48 hours of the onset of the attack, indicating the need for early operation. The four cases of early perforation all died.

When confronted with acute cholecystitis in an old and enfeebled individual, it would seem to be good judgment to perform a simple cholecystostomy, preferably under local anesthesia. This policy was pursued with our patients at first. Of ten patients for whom cholecystostomies were performed, four recovered and six died. Two of the six deaths were due to peritonitis, which in both instances was found present at operation, due to perforation. (The other four deaths were ascribed to cerebral accidents, pneumonia and heart failure). Later, influenced by the trend to cholecystectomy, we performed nine cholecystectomies for acute cholecystitis, with or without gangrene, and of these, five patients recovered and four died, two of peritonitis which was present at operation.

With cholecystectomy showing a 44 per cent mortality as against a 66 per cent mortality for cholecystostomy in old patients with acute cholecystitis, removal of the gallbladder would seem to be the operation of choice. But such a conclusion fails to take into account the patient's coincidental ailments. Where cholecystostomy was done, it was usually because the surgeon did not dare to do the preferred cholecystectomy because of the patient's condition. In both cholecystectomy and cholecystostomy, already established peritonitis accounted for roughly half of the deaths and removal of the gallbladder gave but little advantage in this one particular for which its added risk would seem to justify it as an emergency measure.

Of the total of 34 operated cases, 13 recovered and 21 died, giving a mortality rate of 62 per cent. Four deaths were due to peritonitis, six to pneumonia, six to cardiac decompensation or coronary infarction. There was one death each from cerebral accident, parotitis, multiple liver abscesses, gas bacillus septicemia and exacerbation of chronic osteomyelitis of the femur. The average length of survival of those who died was to the 25th postoperative day. It is assumed that the four surviving cases of carcinoma died later.

Delay in determining the cause of jaundice and reluctance to undertake surgical measures for its relief because of the grave risk involved has, we believe, worked to the disadvantage of some of our patients. It was difficult to decide when the time spent in preparation of the patient for operation began

to run against him in view of the rapidly increasing deleterious effects of jaundice and inflammation.

TABLE IV

ACUTE CHOLECYSTITIS AND COMMON DUCT OBSTRUCTION

Cases: 34 Average Age: 73
(Minimum: 61 Maximum: 91)

Preoperative Condition		Day of Operation		Cause of Death	
Arterio-sclerosis	27	Cholecystitis (av.)	3	Peritonitis	4
A. S. H. D.	19	Obstructed duct (av.)	10	Pneumonia	6
Diabetes	1			Cardiac failure or coronary	6
Pyelonephritis	3	Anesthesia		Cerebral accident	1
Nephritis	14	Cyclopropane	22	Other causes:	
Cerebral accident	3	Local	11	Parotitis	1
Coronary accident	3	(Local with pentothal, 1)		Liver abscesses	1
Valvular H. D.	1	Ether	1	Gas bacillus septicemia	1
Tbc. (miliary)	1			Septic fractured hip (pinned)	1
C. N. S. Lues	1			(Late deaths carcinoma, 4)	
Amyotrophic lateral sclerosis.	1				
Paralysis agitans	1			Death on postoperative day (av.)	25
Operative Condition				**Result**	
Cholecystitis	19			Recovered	13
(Perforated or gangrenous, 7)				Died	21
Obstructed common duct	15			Total mortality rate	62%
(6 with cholecystitis)				Cholecystitis	50%
Biliary carcinoma	5			Obstructed duct	73%
Biliary stone	10				

ACUTE INFECTIONS

Miscellaneous infections provided another group of emergencies requiring treatment regardless of the patient's age. Their management followed established principles of surgical procedure. Prompt and adequate drainage seemed to be even more urgent than in the younger age groups because of its rapidly damaging effect upon old and poorly vascularized tissues and because of poor systemic resistance.

The liberal and intensive use of the antibiotics in recent years has not succeeded in avoiding surgery for the control of local infective processes in these patients.

It was interesting to note the high incidence of septic arthritis occurring in this group. Apparently of hematogenous origin and without evidence of marked arthritis or of injury, this infection occurred nine times in our 36 cases. The shoulder joint was involved seven times, the hip once, and the elbow once. Ischio-rectal abscess occurred in eight cases. The other infections were scattered.

The physical status of the patients and the nature and severity of intercurrent disease were more important in their response to treatment and in the outcome than was age alone. The diabetics presented the most trying problems. Continuing or uncontrolled sepsis was the most common cause of death. The total mortality was 21 per cent.

TABLE V

ACUTE INFECTIONS

Cases: 36 Average Age: 73

Preoperative Condition	
Arterio-sclerosis	30
Diabetes	6
Arterio-sclerotic heart disease	15
Nephritis	9
Coronary disease	1
Cerebral hemorrhage	2
Prostatism	2
Paralysis agitans	2
Pneumonia	2
Fractured femur	2
Cirrhosis	1
Decubitus	3
Pyelonephritis	1

Site of Infection	
Septic arthritis	9
Ischio-rectal	8
Carbuncles	3
(Neck—1)	
(Back—2)	
Cellulitis	11
(Toe — 2)	
(Finger — 2)	
(Hand — 2)	
(Foot — 3)	
(Buttock — 1)	
(Sacrum — 1)	
Empyema	2
Perinephric abscess	1
Ludwig's angina	1
Gangrenous ulcer (Microaerophilic)	1

Operation	
Drainage	33
No operation (died)	3

Anesthesia	
Vinethene	1
Local	9
Pentothal	3
Cyclopropane	19
Ether	1

Postoperative Complications	
Pneumonia	2
Sepsis	5

Cause of Death	
Pneumonia	2
Sepsis	5

Day of Death	
Operated Cases (av.)	8

Results	
Recovered	26
Died	7
Mortality rate (operated cases)	21%

SUMMARY

	Average Age	Number	Recovered	Died	Percent
Amputations	72	65	40	25	38
Obstructions	81	52	23	29	55
Appendicitis	71	5	3	2	40
Biliary	73	34	13	21	62
Infections	73	32	25	7	21
Total	74	188	104	84	44

CONCLUSIONS

1. Among old people suffering from chronic or degenerative disease, there occasionally occur surgical emergencies which urgently require operation to save life.

2. One hundred eighty-eight indigent patients of average age 74 were operated upon for surgical emergencies at the Goldwater Memorial Hospital in a seven-year period. These conditions consisted of gangrene of the extremities, intestinal obstructions, inflammations and obstructions of the biliary system, appendicitis, and various infections.

3. Such conditions often presented difficulties of diagnosis which delayed their recognition.

4. These patients presented poor operative risks and required maximum preoperative supportive and preparatory treatment. Such measures could not always be pursued to the desired extent without unduly delaying surgical relief.

5. Operations were designed to meet the emergency with the least injury and shock to the patient.

6. General anesthesia, properly chosen and administered, was well tolerated by such patients.

7. The postoperative period required attentive nursing and supportive and protective measures, including transfusions, the antibiotics, adequate alimentation, and minimum confinement to bed.

8. The mortality rate was 44 per cent. The preexisting ailments of the patients were the greatest factor in this mortality.

9. Pneumonia was the major cause of death (34 per cent of deaths). Forty-nine per cent of the pulmonary complications began ten days or more after operation.

10. Complications not directly attributable to the operation or to the emergency for which it was performed, accounted for about half of the deaths.

11. Prompt treatment may save well over half of the victims of acute surgical emergencies in old and chronically ill people.

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DISCUSSION.—DR. FREDERIC W. BANCROFT, New York: I have had the opportunity to read Doctor Cutler's report in full and in many ways I am sorry that he has had to cut the contents of this report in order to stay within the time limit allowed for reading the paper.

In 1930, of a total population of 123 million, 14 million reached the ages of 50 to 64, and 6,600,000 were 65 or over. It has been estimated that by 1980 we will have 25 million people over 65 years of age.

It is obvious that we must realize the importance of surgery in the older age groups. I agree with Doctor Cutler that in the older age groups, after affecting hydration and with the necessary blood for replacement at hand, delay for refinements in diagnosis may lose a patient. Immediate surgery is often the *sine qua non*. Also, I agree with him that early mobilization is particularly urgent in the aged. Twenty years ago while at the Lincoln Hospital, I got older people out of bed on their fourth or fifth postoperative day in order to decrease the incidence of pulmonary complications.

In the short time given to me, I am going to confine most of my remarks to mid-thigh amputations. My experience at the City Hospital makes me disagree with Doctor Cutler in the type of mid-thigh amputation he advocates. Our mortality in diabetic and arteriosclerotic gangrene with muscle-cut amputations was distressing. We were using the mid-thigh muscle flap technic. At the same time, I was impressed with the better results being obtained at the Veterans Hospital in the same type of case by a modification of the Callander operation as devised by Dr. Allen Fuller, Chief Surgeon at the Veterans Hospital.

As this amputation embodies certain fundamental surgical principles, I should like to describe briefly his operation. A circular incision is made just distal to the patella. Immediately towel clamps are applied to the skin and deep fascia as the incision is made around the entire circumference. This procedure prevents the separation of the delicate areolar tissue which connects skin and fascia and protects the circulation of both. These clamps are kept on during the entire operation. After the external hamstrings are severed, a finger is passed between the popliteal vessels and the posterior surface of the knee joint. A tape is passed blindly around these vessels and securely tied. The patella is excised and the femur is hugged closely, pushing the muscles upward until they have been separated for a distance of six or eight inches above the condyles. The femur is then sawed through with a Gigli saw and the leg is removed. Then the muscles with the attached skin and fascia are allowed to drop over the end of the femur, the tape is removed and individual vessels are separately tied and the sciatic nerve is appropriately treated. The fascia and skin may then be united without tension.

Tables I and II show the decrease in mortality at the City Hospital and at the Veterans Hospital with this type of procedure:

TABLE I

AMPUTATIONS ABOVE THE KNEE

City Hospital	*Amputations*	*Deaths*	*Mortality Percentage*
Previous to 1937	57	31	54.4
1938-1941	63	39	62
Sleeve amputations	13	4	33.4
Sleeve amputations plus refrigeration	13	2	15.4
Veterans Hospital			
Sleeve amputations	33	8	24

TABLE II

MORTALITY—VETERANS HOSPITAL

Total 103 Cases	*Days: 1–10*	*10–30*	*Over 30*	*Total Per Cent*
Below Knee 60	10%	4%	0%	14%
Knee 33	18%	3%	3%	24%
Mid Thigh 10	10%	0%	20%	30%

Mortality rate, 103 cases —— 19 deaths —— 18%

Average age all patients..... 50

Average age all *deaths* 59

Tables I and II show the decrease in mortality with the Fuller type of sleeve amputation at the lower thigh.

If time permits, I should like to state briefly some work that has been done by Ned Schnayerson at Welfare Island to decrease the number of amputations in the older age group. He has taken arteriograms of people with intermittent claudication and found that often there are blocked segments of the femoral or popliteal arteries. He considers these blocked segments to act as nerve stimuli creating venospasm. By excising these segments and being careful not to interfere with the collateral circulation, he has had some astonishing results. One patient who could walk only two blocks is now walking eight miles. Minor amputations have been done with satisfactory healing.

DR. CONDICT W. CUTLER, JR., New York (closing): I am very much indebted to Doctor Bancroft for his discussion. He understands our problems so well, having worked in the same general line for many years, and recognizes the difficulties that confront us in aged patients. The observations he has made concerning amputations I think are particularly helpful, and we should be encouraged toward less radicalism if it were not for two facts: the vessels and tissues in the lower third of the thigh, especially where diabetes is present, are likely to be already involved in the sepsis; and in arteriosclerosis, where the vessels are already occluded at that level, one may not do an amputation with the hope of securing adequate circulation in the stump. We have done the Callander amputation and also the sleeve-type modification. Of four cases one required reamputation because of sepsis. Two were done below the knee and one developed gas infection and required reamputation. Fifty-six guillotine amputations were done. In 46 there was suture of the muscles and skin; 30 suppurated, 2 with gas infection. In 16 the skin alone was sutured and six suppurated. That discouraged us from thinking we could safely perform either flap or Callander operations in the septic cases.

Our patients requiring emergency amputation averaged 72 years of age. In the 25 who died, four died of conditions directly attributable to operation; three of shock, one of sepsis. The others died for the most part of pneumonia or from unrelated causes which resulted in death up to a month after operation.

In this report we have not attempted to adjust the mortality figures in our favor. It must be recognized that a good many patients would not have died had they not required operation, and it seemed unfair to excuse the deaths on the basis of pre-existing disease. So we have accepted responsibility for the deaths as long as the patients were in the hospital and under our care. We hope to be able to do better, but I think it is right to face the issue squarely and recognize that in the chronically ill aged patient, particularly in surgical emergencies, we do have a problem of considerable and increasing magnitude.

EXPERIENCES IN THE SURGICAL TREATMENT OF MULTIPLE VISCERAL NEOPLASMS*†

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THE OCCURRENCE OF MULTIPLE VISCERAL NEOPLASMS is of interest because of the implications in regard to etiology. Several collective reviews have appeared in the literature in recent years[1-6] based for the most part upon necropsy findings. In view of the increased efficiency in the surgical treatment of neoplasms which has resulted in a greater incidence of prolonged survival following the treatment of one growth, the question of multiple neoplasms occurring simultaneously or developing successively assumes added clinical importance.

The following discussion is based upon a clinical experience with nine patients presenting multiple symptom producing visceral neoplasms. They have been classified into three groups: A. Those with multiple tumors closely situated to one another and producing symptoms clinically accountable by one growth. In these patients the multiplicity of the growths was discovered only at operation or upon study of the pathologic specimens. B. Those with two tumors rather widely separated and manifesting simultaneously the symptomatology of two separate growths. C. Those in whom one growth was excised to be followed later by the development of a second independent growth, which in turn was also resected.

CASE REPORTS

Group A.

Case 1. (Fig. 1A)—F. O., male, 59 years old, admitted June 27, 1945, complaining of epigastric pain aggravated by eating, and vomiting, three months; loss of 15 pounds weight during the same period. Roentgenograms revealed "an obstructing lesion in the pylorus, 3 to 4 cm. proximal to the duodenal bulb." Gastroscopic examination revealed an ulcerating polypoid mass as far as the angelus—impression, carcinoma.

On July 3, 1945, laparotomy was performed and a typical carcinomatous process discovered in the lower stomach. Palpation of the first segment of duodenum revealed a small rounded boggy mass that seemed to extend backward into the stomach. Radical gastrectomy including the first segment of duodenum was carried out and a Polya type of gastrojejunostomy performed.

Study of the opened stomach showed a flat carcinomatous ulcer 5 cm. in diameter in the pre-pyloric region; beyond this was a yellowish rounded mass 1.5 cm. in diameter attached by a narrow base to the mucosa just proximal to the sphincter. The most protruding portion of the mass projected through the sphincter itself into the first segment of duodenum. This was obviously a pedunculated lipoma producing a ball-valve stoppage at the pylorus. Histologic examination confirmed the carcinomatous nature of the former

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lesion and the fact that the latter growth was a lipoma. One year and six months after operation, the patient remains well. (Case previously cited).

Case 2. (Fig. 1B)—F. Z., white male, age 46, admitted January 29, 1945, complaining of vomiting of "heavy foods" during previous five weeks, epigastric "fullness" for seven weeks and 25 pounds loss in weight for six months. Roentgenographic examination of the stomach revealed "ulcerating polypoid neoplasm of the gastric antrum."

Celiotomy was performed Feb. 5, 1945, at which time what appeared to be a large infiltrating carcinoma was encountered in the pylorus with infiltration into the transverse

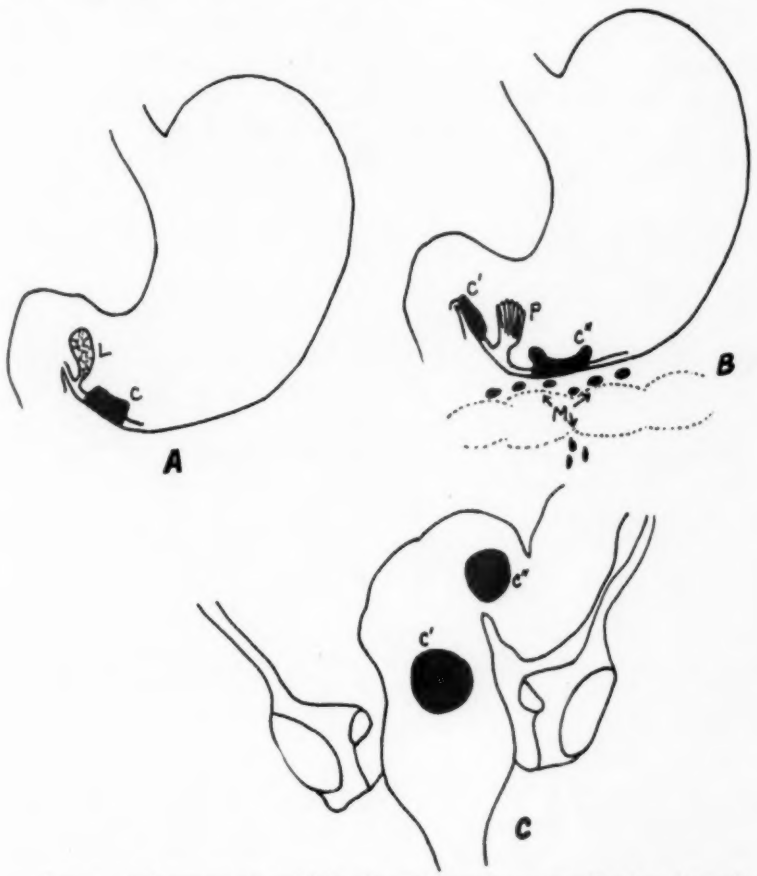

FIG. 1.—Diagrams of multiple visceral neoplasms manifesting themselves clinically as one growth.

A. Case 1. L, pedunculated lipoma in pylorus; C, carcinoma in prepyloric region. The former might well have produced obstructive symptoms.

B. Case 2. C′, scirrhous carcinoma in pylorus; P, papilloma in prepyloric region; C″, ulcerating carcinoma proximal to the latter. M, metastases in transverse meso-colon and about the superior mesenteric vessels.

C. Case 3. C′ and C″, two separate primary carcinomas in pelvic colon. Patient 83 years of age at time of successful resection.

meso-colon almost to the colon itself and with metastases to lymph nodes about the superior mesenteric vessels. A radical gastrectomy with resection of most of the transverse colon and its mesentery together with the metastatic nodes about the superior mesenteric vessels was carried out. Polya gastro-jejunostomy and double barrel colostomy. The latter was closed four weeks later.

Study of the surgical specimen (stomach) when opened revealed three separate neoplasms along the greater curvature (Fig. 2). The first, a scirrhous carcinoma presented as a flat ulceration 2.5 cm. in diameter just proximal to the pyloric sphincter. Two cm. proximal to this was a benign papilloma with small base. The lesion measured 3.5 cm. in greatest diameter. Separated from the base of the papilloma by .5 cm. of normal mucosa was a second carcinomatous ulcer with raised rolled edges measuring 6.5 cm. in diameter. There were many metastatic nodes. The patient did well and

FIG. 2.—Photograph of surgical specimen consisting of opened resected lower three-fourths of stomach exhibiting three separate neoplasms: C, scirrhous carcinoma in pylorus; P, pedunculated papilloma; U, ulcerating carcinoma. Study of the specimen revealed small areas of normal uninvolved gastric wall between each of these lesions. N, portion of metastatic nodes removed from about the superior mesenteric vessels. The transverse colon and meso-colon were also resected because of secondary involvement but are not shown in the photograph. The patient lived for one year to receive palliation for most of this period.

returned to work for several months. However, in Dec. 1945, there was severe back pain and dyspepsia. He was finally readmitted to the hospital and died Jan. 27, 1946, necropsy revealing carcinomatosis.

Case 3. (Fig. 1C)—J. F., white male, 83 years of age, admitted Aug. 10, 1945, complaining of severe constipation and tarry stools for one year; bleeding from rectum and pain in the rectum for six months. On rectal examination a polypoid carcinomatous mass was palpated at the tip of the finger.

Celiotomy was performed on Aug. 18, 1945, because no metastases were palpated,

a typical combined abdomino-perineal resection was performed. Study of the 30 cm. of lower colon removed showed two separate raised, circular ulcerating carcinomas, one 8 cm. above the anus and one 6 cm. above the first growth. The lower one measured 3 cm. in diameter, the upper one 6 cm. in diameter. Sections showed metastases in one of eight lymph nodes examined.

Sept. 1947, two years and one month after operation, the patient is well and normally active.

Group B.

Case 4. (Fig. 3A)—F. N., male, 58 years, admitted May 25, 1946, complaining of difficulty in swallowing, especially solid foods, for the past three months; loss of 15 pounds in weight during the previous four months; "gas on stomach" following ingestion

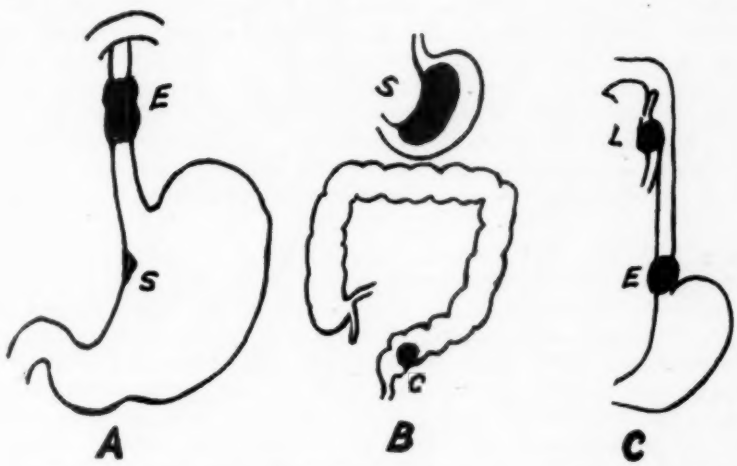

FIG. 3.—Diagrams of multiple visceral neoplasms manifesting themselves simultaneously as two separate growths.

A. Case 4. E, carcinoma of lower third of esophagus and S, carcinoma on lesser curvature of the stomach.

B. Case 5. S, carcinoma involving the major portion of the stomach. C, carcinoma of the pelvic colon.

C. Case 6. L, carcinoma of the larynx; E, carcinoma at the cardio-esophageal junction.

of certain foods, for the past one and one-half years. Roentgenographic examination revealed a small partially obstructing neoplasm in the lower esophagus.

On May 31, 1946, a left thoracotomy was performed removing the 8th rib. A carcinoma was found in the mid-portion of the lower half of the esophagus measuring about 8 cm. in length. When the diaphragm was incised for mobilization of the stomach and the latter brought upward a small firm lesion was discovered on the lesser curvature. The stomach was opened and the latter observed to be a sharply penetrating ulceration. It was excised by elliptical incisions and the stomach repaired. The lower 2/5 of the esophagus and upper fourth of the stomach were then resected, the stomach closed and brought upward for esophago-gastrostomy by the usual method.

Histologic study revealed the esophageal lesion to be a squamous cell carcinoma. Sections of the gastric lesion revealed it to be an adenocarcinoma. Sections of the small mass from the liver revealed it to be a focus of necrosis with inflammatory reaction. No evidence of neoplasm was here observed.

Convalescence was uneventful and he was discharged on the 12th day postoperative.

Case 5. (Fig. 3B)—M. W., white male 62 years of age, admitted April 24, 1945, complaining of loss of 10 or 15 pounds in weight during the previous three months, increasing constipation for the past three years, and a feeling of fullness in the epigastrium of 4–5 months duration. Roentgenographic examination of the stomach revealed "one and possibly two ulcers almost certainly due to neoplastic involvement." Proctoscopic examination revealed an ulcerating polypoid carcinoma at 10 cm. distance.

On April 28, 1945, an upper abdominal laparotomy was performed and a large tumor mass involving almost the entire lesser curvature of the stomach was found; palpation in the pelvis revealed a firm neoplastic mass in the rectal colon below the peritoneal reflection. No lymph node or hepatic metastases were found in the upper or lower abdomen. A total gastrectomy was performed. Histologic study confirmed the presence of adenocarcinoma. Following satisfactory recovery from this procedure, a one stage combined abdominoperineal resection was carried out on May 24, 1945, with removal of the terminal 24 cm. of colon. In the lower portion an oval carcinoma **3 x** 2 cm. was present. Histologic study confirmed the diagnosis of adenocarcinoma and sections from three lymph nodes failed to reveal metastases. Convalescence was again satisfactory except for symptoms of prostatism. On June 22, 1945, a transurethral electro-resection was done by Dr. W. W Scott. He was finally discharged on July 14, 1945. In January, 1947, one year and nine months after operation, the patient is well and normally active, but there is a small fistula at the site of the perineal wound (no evidence of recurrences). The appetite is good.

Case 6. (Fig. 3C)—N. I., Japanese male, 63 years of age. In June, 1946, the patient experienced epigastric pain related to the swallowing of solid foods and later induced even by the swallowing of soft foods. There was also hoarseness said to exist for "three or four years." Laryngoscopic examination in August, 1946, revealed a carcinoma of the right true vocal cord. Histologic study of a biopsy confirmed the diagnosis. He received irradiation therapy to the larynx at the Chicago Tumor Institute under direction of Dr. Max Cutler. The laryngeal neoplasm subsequently resorbed completely. On Oct. 2, 1946, he was admitted to the University of Chicago Clinics where roentgenographic studies revealed a lesion typical of carcinoma at the cardioesophageal junction.

On Oct. 8, 1946, a left transthoracic cardioesophagectomy was performed removing the lower third of the esophagus and upper fourth of the stomach together with the contiguous portions of the diaphragm because of invasion by tumor. The stomach was brought upward into the mediastinum and esophago-gastrostomy performed. The immediate postoperative condition was satisfactory but the patient expired suddenly on the afternoon of the third day. Necropsy revealed no adequate explanation for death. There was no hemorrhage, nor evidence of infection. Histologic study of the laryngeal biopsy and of the lower esophageal growth showed both to be squamous cell carcinomas but of different histologic types.

Group C.

Case 7. (Fig. 4A)—A. G., white female, age 52. Two years previously a carcinoma of the sigmoid had been resected by the "Mikulicz procedure" in another institution. The histologic diagnosis was confirmed. Admitted Oct. 20, 1937, complaining of "several severe hemorrhages from the bowel." A barium enema revealed a large spherical smoothly outlined filling defect in the right portion of transverse colon just distal to the hepatic flexure.

On Oct. 25, 1937, laparotomy was performed and the lesion observed through the stretched but intact colon wall. It was obviously a lipoma, 6 cm. in diameter. The involved segment of colon bearing the tumor was exteriorized, cut away, and the resultant double barrel colostomy subsequently closed. During the operation exploration of the liver, upper and lower abdomen failed to reveal evidences of metastases.

The patient remains well ten years later.

Case 8. (Fig. 4B)—M. B., white female, 54 years of age, admitted complaining of dull epigastric pain, non-radiating, intermittent and associated with rumbling sounds in the abdomen. There had been alternating liquid and formed stools—duration of complaints, "over two months." Barium enema revealed an annular constricting lesion in the cecum.

On Dec. 2, 1940, a right hemicolectomy with ileo-transverse colostomy was performed. Convalescence was uneventful for 18 days when a deep right flank abscess was discovered and drained and a week later she was discharged.

Study of the surgical specimen which consisted of the right half of the colon revealed

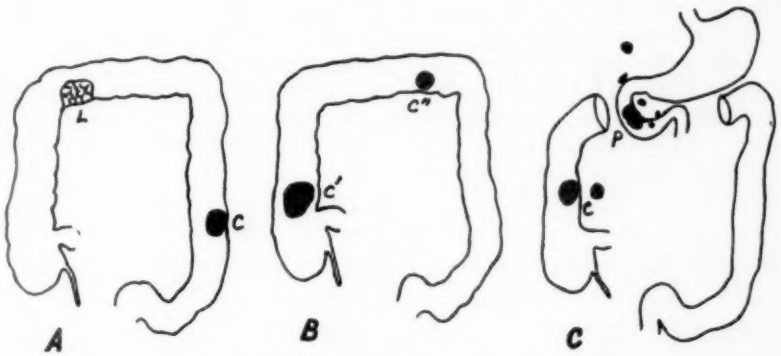

FIG. 4.—Diagrams of multiple carcinomas or benign tumor occurring successively and successfully resected.

A. Case 7. C, carcinoma of descending colon resected in 1935; L. large pedunculated lipoma causing hemorrhage and partial obstruction resected in 1937. Patient well in 1947.

B. Case 8. C′, carcinoma of ascending colon resected in 1940. Well until 1946 when because of obstruction was re-operated upon and found to have what was apparently another primary growth near splenic flexure C″, and also liver metastases. Jan. 1947, alive but has deteriorated due to advancing carcinoma.

C. Case 9. P, large carcinoma of papilla of Vater with regional lymph node metastases resected in May, 1943. C, carcinoma of ascending colon with regional lymph node metastases resected in November, 1945. March, 1947, patient well and returned to usual occupation.

an annular carcinoma 4 cm. in width in the cecum. Histologic study showed metastases in two of 13 nodes examined.

The general condition remained satisfactory until Aug. 9, 1946, at which time she was admitted to the Woodlawn Hospital (Chicago) under the care of Dr. H. P. Jenkins, complaining of abdominal pain, nausea and vomiting of five days duration. Barium enema revealed some evidence of constriction in the colon near the splenic flexure. The abdomen was decompressed with the Miller-Abbott tube and the patient discharged. She was readmitted as above on Sept. 8, 1946, after repeated attacks of obstruction at home.

Celiotomy was performed (Doctor Jenkins) on Sept. 12, 1946. Many adhesions were encountered; a tumor mass was palpated in the transverse colon near the splenic flexure. There were numerous metastases throughout both lobes of the liver. The area of the ileo-transverse colostomy was identified. The remaining portion of transverse colon bearing tumor was exteriorized and later resected with closure of the colostomy. She was discharged with colostomy closed.

Pathologic study of the specimen showed a primary carcinoma in the left portion of the transverse colon a short distance proximal to the splenic flexure.

Case 9. (Fig. 4C)—N. G., white male, age 53, admitted April 4, 1943 complaining of icterus of varying severity, two months duration, and constipation, noticeably aggra-

vated in the previous eight months. Roentgenographic examination showed a papillomatous growth in the region of the papilla of Vater. On May 17, 1943, a one-stage pancreatoduodenectomy was performed for excision of a large papillary carcinoma of the ampulla with regional lymph node metastases. One metastatic node was high in the porta hepatis over the junction of cystic duct with common duct. Convalescence was satisfactory and following discharge he returned to work.

By November, 1945, there was again loss in weight and discomfort in the right abdomen. A questionable mass was palpated deep in the right flank. In February, 1946, this finding had become definite and he was readmitted to the hospital where another laparotomy was performed on March 6, 1946. The upper abdomen and liver exhibited no metastases. A cirrhosis of the liver noted at the first operation was now seen to be more pronounced. In the mid-portion of the ascending colon there was a papillary carcinoma about 4 cm. in diameter with obvious lymph node metastasis in the corresponding mesentery. A right hemicolectomy was uneventful and the patient returned to his usual occupation. He is well one year and six months after the second operation and 4 years and 6 months after the initial operation.

DISCUSSION

The colon is a relatively common site for multiple malignant tumors in the abdominal viscera. In a review of 726 histologically verified cases from the University of Rochester, N. Y., series Mider found 21 instances of multiple malignant growths in the colon. There were four instances in which the neoplasms manifested themselves successively; two died, and two survived. One of the latter presented a neoplasm at the splenic flexure in 1938, and in 1942 had carcinomas in the rectum and descending colon respectively. He remains well three years after the last operation. The other patient, a female, presented a carcinoma of the cecum in 1928 and one in the transverse colon in 1929. She is apparently well 16 years later, after resection.

There were nine cases of multiple malignant neoplasms present synchronously in the colon and surviving eight to 78 months after resection.

Slaughter, in an excellent collective review of the whole subject of multiplicity of origin of malignant tumors, also noted that, with the exception of the skin, the colon was by far the most frequently involved of all the organs.

In the series reported above, the stomach was the site of multiple neoplasms in two instances; the colon in three instances; the larynx and esophagus in one instance; the esophagus and stomach in one instance, the stomach and colon in one instance, the papilla of Vater and colon in one instance. All lesions were not malignant. In two instances one of the stomach was benign and in one instance one of the colon lesions was benign, but in two of these the benign lesions produced symptoms.

The classical teaching is to ascribe as often as possible, all symptomatology to one pathologic process. In the case of neoplasms, especially malignant, recurrence of symptomatology in the great majority of instances is due to recurrence of the neoplasm and/or its metastases. However, sufficient data has now been published to indicate that the multiplicity of neoplasms producing symptoms synchronously or successively as they develop, is not an extreme rarity and in the follow-up of patients having had one neoplasm resected this possibility is to be borne in mind.

SUMMARY

The case histories of nine patients are reviewed in which there was multiplicity of malignant or benign symptom producing neoplasms of various viscera. The details of management are discussed.

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RESECTION AND PRIMARY ANASTOMOSIS IN THE TREATMENT OF GANGRENOUS OR NON-REDUCIBLE INTUSSUSCEPTIONS IN CHILDREN*

A Safe, Simple, One-Layer Silk Anastomosis

CLARENCE DENNIS, M.D.

FROM THE DEPARTMENT OF SURGERY, UNIVERSITY OF MINNESOTA HOSPITALS. SUPPORTED BY A RESEARCH GRANT FROM THE GRADUATE SCHOOL OF THE UNIVERSITY OF MINNESOTA

A REVIEW OF THE LITERATURE on the management of recurring, irreducible, and gangrenous intussusceptions offers little evidence of a satisfactory solution of the problem. Wangensteen's review indicates that to the time of publication (1942) no series of cases of resection had been reported without very high mortality. Other methods have also been employed, such as the short-circuiting procedures of Rutherford and of Montgomery, or the cutting of the intussuscipiens by Brown, but most authors seem to favor exteriorization. Of primary anastomoses, the case of Dowd is among the earliest successes, but the experience of Perrin and Lindsay with nine survivors in 29 attempts and of Hipsley with none surviving is more usual.

Success in a case of gangrenous intussusception in 1940 prompted the author to employ resection and primary anastomosis routinely for strangulating obstructions. Success in other types of cases led to confidence in application of the method to more intussusception cases. At the University of Minnesota Hospitals, intussusceptions rarely arrive in the first 24 hours, and the experience therefore has been that almost 50 percent of these cases have required resection between November 1940 and March 1, 1947.

CASES TREATED

Case 1.—U. H. #702210, male, age 39 days, was admitted November 20, 1940, in a dehydrated state with a 60-hour history and findings typical of intussusception. The abdomen was tympanitic and distended. He was transfused and given 100 cc. of 0.9 per cent NaCl solution before operation, and was slowly transfused during operation, which was done under open ether. Through a right lower rectus incision, an ileocolic intussusception was identified, and the apex was milked back into the ileum, but the lesion could not be completely reduced despite considerable manipulation; efforts were terminated by occurrence of a serosal tear. The upper margin of the intussuscipiens was observed at this point to be discolored, edematous, and firmly sealed to the bowel above. Exteriorization was considered at this point, but the mesoileum was not long enough to permit it. The involved area was therefore resected from a point 2 cm. above the ileocecal junction to a site 5 cm. above the upper margin of the intussuscipiens, and an aseptic, end-to-end anastomosis of the Martzloff-Burget type was performed with catgut used for the internal layer. About one gram of sulfanilamide was implanted, partly about the anastomosis and partly in the wound, during catgut closure.

After operation the patient was given 100 per cent oxygen, nasal gastric suction, and intravenous sulfathiazole for 36 hours. Feces were passed at 48 hours, and the

* Read before the Meeting of the American Surgical Association, March 25–27, 1947, Hot Springs, Va.

temperature reached normal at 72 hours. Early feeding was cautious, but the patient improved rapidly. Dismissal was delayed until 22 days postoperatively by late development of bronchopneumonia. He was last seen four months later, and seemed a normal baby at that time.

The specimen presented areas of necrosis, and there was hemorrhagic infiltration of the gut wall.

Case 2.—U. H. #703673, female, age four months, was admitted January 20, 1941, with a 21-hour history and findings typical of intussusception. After hydration, transfusion, and ether anesthesia, the intussusceptum was found to have progressed into the descending colon, the base of the cecum not being inverted. It was manipulated back into the terminal ileum; here a necrotic area came into view, and perforation occurred. The mesentery being long, the area was exteriorized over a glass rod, using silk abdominal closure. The double-barreled ileostomy was opened in two days, but the baby had a bout of partial obstruction and fever which lasted five days. Thereafter, she gradually lost weight and strength despite forced feedings and free drainage from the ileostomy. After vigorous intravenous preparation, the ileostomy was closed, using a Martzloff-Burget anastomosis, on February 24th, with implantation of a gram of sulfanilamide. She again had prolonged postoperative ileus and fever, and did not pass stool until five days later. Following a bout of pneumonia, she finally recovered, and was dismissed 61 days after admission.

She was last seen a month later at which time she was considered normal.

Following the rather precarious course of this patient, it was decided to employ primary closed anastomosis on these cases in the future.

Case 3.—U. H. #714167, male, age 11 months, was admitted October 31, 1941, with a 40-hour history. After preparation, laparotomy under open ether permitted reduction of the apex from the hepatic flexure to a point 25 cm. above the ileo-cecal junction. Here necrotic bowel prompted resection without complete reduction. Thirty centimeters was resected, and a Martzloff-Burget anastomosis was made using catgut for the inner layer, with dusting of 2 Gm. of sulfathiazole about the anastomosis.* Although old blood was passed by rectum within a day, removal of gastric suction was not tolerated until one week after surgery. Dismissed at 26 days, delayed by abscess at site of venesection.

The patient was last seen six weeks later, and was well.

The specimen showed widespread infarction of bowel.

Case 4.—U. H. #729600, male, age 9 years, was admitted March 9, 1943, with a history of blood in the stool at intervals, with cramps, for several months. Acute onset of severe intermittent cramps began 28 hours before surgery. Study showed high small bowel obstruction. Exploration through a right rectus incision under cyclopropane anesthesia revealed a massive high ileo-ileac intussusception with massive adhesions of the margin of the intussuscipiens to the base of the cecum. Following considerable reduction, manipulation was halted by an irreducible portion containing a mass, and by perforation. Sixty centimeters of ileum was resected, and Martzloff-Burget anastomosis with catgut for the inner row was made, implanting about 50 mg. of sulfanilamide between rows, but not elsewhere. Appendectomy. Postoperative course uneventful, with removal of suction in four days. Total hospitalization 11 days.

The patient is in good health at the present time, without anemia or abdominal complaints.

The specimen showed a polyp 6 x 4 cm. with a stalk 2 cm. in diameter, which served as the apex of the intussuscipiens.

* Procedure by L. J. Hay, then resident on Surgery and now National Cancer Fellow at the University of Minnesota.

Case 5.—U. H. #737486, male, age 43 months, was admitted November 17, 1943, with a history of three days of nausea and vomiting and two days of severe cramps coming every 20 to 30 minutes without blood in the stool. Films showed gas in the cecum, and an erroneous diagnosis of colo-colic intussusception was made. Exploration under cyclopropane anesthesia showed a mass near the cecum, which reduced easily before it could be delivered; the terminal ileum remained edematous, and the junction wide open so that a finger could palpate the lumen of the ileum by inversion of the cecal wall. Several sessile polypoid masses could be felt by this procedure in the last three centimeters of ileum.

Five days later, after a smooth course to that time, he developed severe cramps more typical of ileac intussusception in that they came every three to five minutes. Re-exploration through a separate incision. Ileo-colic intussusception was easily reduced, and the same masses were palpated inside the thickened terminal ileum. In the belief they had played a part in the development of intussusception, the last 11 cm. of ileum was resected. Ileocecal junction closed with silk, and end-to-side anastomosis of ileum to ascending colon easily made by Martzloff-Burget plan. Appendectomy. Silk closure.

Postoperative course uneventful. Suction six days. Total stay 24 days. Patient checked and well at six weeks.

The specimen showed a polypoid hyperplasia of a Peyer's patch about 3 centimeters from the ileocecal junction.

Case 6.—U. H. #721360, male, age 24 months, was admitted May 20, 1944, with typical findings and a 30-hour story. Under cyclopropane anesthesia, the apex of an ileocolic intussusception was milked, with considerable manipulation, into the terminal ileum. When complete reduction had been accomplished, an area of necrosis with hemorrhagic infarction dictated resection of a 15 cm. segment some 9 cm. above the ileocecal junction. Oblique, aseptic, end-to-end anastomosis with 180 degree rotation was used because of the very small diameter of the bowel (1 cm.). A few mg. of sulfanilamide was implanted between rows, and in closure of abdomen with silk.

Postoperative course uneventful. Suction three days, full diet at five days, and home in ten days.

The specimen showed extensive gangrene.

Case 7.—U. H. #746278, female, age seven and one-half months, was admitted July 29, 1944, with a history of intermittent pain, vomiting, bloody stool beginning five days earlier and lasting only 12 hours. Thereafter she had taken feedings and had normal stools. A day later developed fever, anorexia, and then vomiting. Admitted with temperature 104, Hgb. 5.1 Gm. per cent, pus and casts in urine, and negative abdomen. After admission she developed severe distention; surgical consultation eight days after onset of trouble.

Patient was explored under cyclopropane anesthesia with diagnosis definite only as to high small bowel obstruction. Hugely distended ileum precluded exploration until aseptic decompression, removing 200 cc. gas and 200 cc. feces.[19] An ileocolic intussusception was reduced easily. A second intussusception was found 25 cm. higher. After reduction, a Meckel's diverticulum was found at the apex. It was observed a few minutes because of doubtful viability; during this time redevelopment of intussusception at the area was seen to be occurring. This area was resected and an aseptic, oblique, end-to-end anastomosis with 180° rotation was made, with 20 mg. sulfanilamide between rows. Silk closure.

Postoperative course was complicated by separation of a portion of the wound at six days, with extrusion of a tag of omentum, and drainage. Treated conservatively with taping because of fear of peritoneal infection. Suction out at six days. Course also complicated by poor renal function, the blood urea nitrogen level reaching 105 mg. per cent at five days. This gradually improved on withdrawal of sulfadiazine. There was some

abdominal distention at intervals, but she gained weight and strength. Hospitalization was prolonged for mandelic acid therapy of the urinary infection. Total stay 78 days.

The patient returned for hernia repair June 13, 1945, weighing 11.6 kg. (18 mo.). Discharged in apparently excellent condition thereafter.

Case 8.—U. H. #772340, male, age five and one-half months, was admitted October 27, 1946, with a four-day story and physical findings classical for intussusception. Very lethargic and dehydrated. After hydration and transfusion, the abdomen was opened through a right lower quadrant oblique incision under local and cyclopropane anesthesia. The right colon contained intussusceptum, the base of the cecum and appendix being involved, and manipulation failed completely. A right hemi-colectomy was therefore performed, with surprisingly little difficulty, and a single-layer closed silk end-to-end anastomosis was made between the ileum and the transverse colon. Gaseous distention of the small bowel was relieved by aspiration of 160 cc. of air with silk inversion of the puncture site, following which silk closure was easily accomplished.

The postoperative course was smooth. Fever disappeared and feedings were easily started the same day the nasal gastric tube was removed, 48 hours after surgery. The total hospital stay was 11 days.

Patient was last seen a month later and was doing nicely at that time except for occasional stools softer than normal.

The specimen showed the apex of the intussusceptum to be the base of the cecum, which was gangrenous.*

THE CHOICE OF PROCEDURE

Cases requiring resection may at the present time be managed either by exteriorization or by resection and primary anastomosis. In their book, Ladd and Gross favor exteriorization and report seven recoveries in 25 cases. Gross is preparing a report at the present time on 10 successive cases treated in this fashion, with crushing of the spur early, and closure of the ileostomy before serious nutritional disturbances can occur. Nine of the 10 cases recovered, a record which is indeed a milestone in a problem the literature of which has heretofore been devoted to failures.

At the University of Minnesota Hospitals, primary closed anastomosis was brought into use by one of these cases and pressed the more vigorously as experience was gained. The advantages of rapid restoration of gastrointestinal function, omission of a second operation, and shortened hospital stay seem to us to be arguments in favor of the method. It must be granted that good fortune has played a major role in more than one of these cases and that the mortality record can hardly remain perfect. It is with some misgivings that so small a series is presented.

* After submission of this paper for publication, the son of one of our surgery residents, age 3, #737852, was admitted for intussusception of 17 hours' duration, on May 23, 1947. It was reduced by barium enema, but recurred 27 hours later. Exploration showed an easily reducible intussusception at the ileocecal junction, which was patulous. Palpation through the inverted cecal wall revealed polypoid masses in the last 3 cm. of ileum. In the belief this situation underlay the recurrence of the intussusception, the terminal ileum was resected, the cecal stoma was closed, the appendix was removed, and a one-layer, silk, end-to-side anastomosis was made to the ascending colon. The postoperative course was uneventful and the patient is well today. The specimen showed a congested Peyer's patch with erosion on the surface.

THE TYPE OF ANASTOMOSIS

In the earliest cases the Martzloff-Burget plan was employed. It is not satisfactory in very slender segments of intestine, however, and for this reason the oblique, aseptic anastomosis with rotation was later employed.[3] More recently, the single-layer silk method used in the last case was adopted.

Method. Anastomosis clamps are placed somewhat obliquely and not quite completely across the prepared bowel about 1 cm. from the remaining edge of mesentery (Fig. 1). The bowel is cut across with cautery as with either of the older methods. Halsted silk (2½-pound test) sutures are placed 7 mm. back from the cut edge of the intestine to be anastomosed (not from the clamp); they are placed first on the back side of the anastomosis and tied, closing the bowel over one blade of both anastomosis clamps. The clamps are then swung to the other side so the anterior wall of bowel can be similarly sutured and tied. Proper initial clamp placement permits closure over the tips of the clamps also. The entire suture line is now complete except at the point of exit of the clamps. Preplacement of two sutures here permits completion of the anastomosis at once after careful removal of the clamps.

In case of questionable viability, wide variation in diameter of the ends to be sutured, or somewhat narrow lumen, the clamps may be placed more obliquely and one end rotated, as in the oblique, end-to-end anastomosis previously described.[3] *

That multiple-layer catgut anastomoses of stomach and intestine should have achieved and maintained general use is perplexing in the face of the demonstration by Halsted of the efficacy and safety of the single-layer silk

* In case of difficulty in closing the bowel over the two clamps in cases in which the diameter of one or both sides is small, loosening or removal of the clamp from the distal or empty segment alone permits easy closure except at the point of exit of the clamp or clamps; this may be facilitated by the use of Lembert instead of Halsted stitches.

FIG. 1.—Closed, one-layer, interrupted silk anastomosis.

a) Placement of first Halsted mattress sutures. Note that the clamps are placed not quite completely across the bowel. The point of exit of sutures closest to the modified Martzloff clamp is 7 mm. from the cut edge of the bowel. If the bowel is less than 2 cm. in diameter, either smaller clamps may be used, or the sutures may be placed immediately adjacent to the clamps and the clamps removed before tying the stitches,[18] or, preferably, the two-layer, oblique, end-to-end anastomosis may be used,[3] best with withdrawal of the inner catgut basting stitch after completion of the silk suture line. When the distance from the cut edge of the bowel to the stitches is more than one-third the length of tissue along the crushing clamps, real danger of obstruction is present.

b) Completion of back side of anastomosis, tying also over ends of clamps.

c) and d) Front side of anastomosis.

e) Removal of clamps—delayed until all but two sutures have been tied.

f) Completion of anastomosis by tying last two sutures after removal of clamps. The total number of sutures for intestinal anastomosis has varied from 11 to 18.

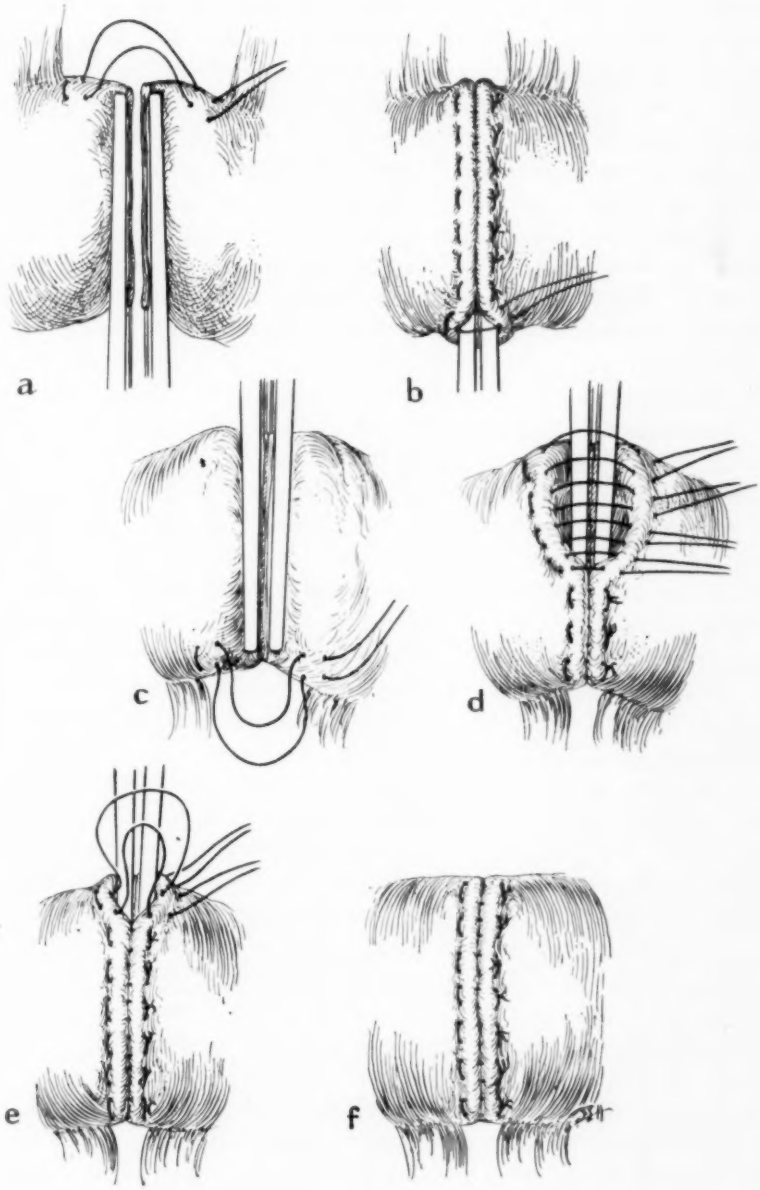

FIG. 1

anastomosis in dogs. It is true that without the closed method introduced to general use by Collins, by Scarff, and by Martzloff and Burget, the silk technique was more cumbersome to use. The feasibility of single-layer silk anastomoses over clamps, as proposed by Scarff, was doubted by Martzloff and Burget because of fear of over-inversion of tissue. F. K. Collins presented a method of end-to-end anastomosis in which the clamp was used only to make secure a previously laid tie about the intestine. His method accomplishes nicely serosal approximation without contamination, but suffers seriously from overinversion of tissue, in the light of my own bad experience. The same criticism seems to hold against the bulkhead method, even as so ingeniously modified by Horine, except in the rectal region, where large diameter and ready proctoscopic availability insure against serious obstruction.

At the University of Minnesota Hospitals, reapplication of the bulkhead method has proven successful for low rectal anastomoses, and Wangensteen had previously found single-layer anastomoses over clamps very satisfactory in the gastroenterostomy of gastric resection, and also in some colon and small bowel anastomoses. Besides the danger of overinversion, an objection to the use of single-layer interrupted silk anastomoses over clamps lies in the possibility of soiling in the process of removing the clamps before the numerous sutures have been tied. It is primarily this that the present method attempts to avoid.

The safety of such an anastomosis was suggested by removal of an inner running catgut stitch because of pursestring effect in ileosigmoidostomy after colectomy for ulcerative colitis in September, 1946. This left a true single line of sutures, whereas Wangensteen's anastomosis is usually done with placement of 30 to 40 sutures, with some staggering so as to accomplish approximation in a broader area than a true single line.

The anastomosis as illustrated above has been used in 19 cases, 5 in the presence of small bowel distention from obstruction. All cases have recovered smoothly save one who had perforation of an obstructed closed loop with generalized peritonitis before surgery and one who had anastomosis of a sigmoid colon after removal of an area of diverticulitis. In the latter case the bowel was 15 mm. in external diameter, and the sutures were placed 8 mm. back from the clamps, with a transverse suture line. Although it was later found a catheter could be passed easily through the anastomosis, the inverted cuffs behaved in valve-like fashion sufficient to cause fatal tension gangrene of the transverse colon. In cases in which the sutures have been placed back of the cut edge of the bowel less than one-third the length of crushed tissue in the anastomosis clamp, there has been no complication.

This conclusion as to amount of inversion has been borne out by trial anastomoses in bowel obtained at autopsy. By use of a 7 mm. distance from the cut edge of the bowel—not from the clamp—it is possible to achieve approximation over the modified Martzloff clamps devised for the oblique anastomosis.[3] Anastomoses so constructed allow free flow of water at less than 1 cm. head of pressure. Intestine less than 2 cm. in diameter

seems more safely anastomosed by the previously described two-layer oblique anastomosis with rotation, with withdrawal of the catgut basting stitch after placement of the silk if desired.

Adoption of this type of procedure was entertained initially as a time-saving measure. It seems regularly, however, to have been followed by a shorter period of postoperative ileus than anastomoses with one layer of catgut in addition to silk (Note case 8, put successfully on feedings two days after operation). Proctoscopic examination of patients who have had bulkhead rectal anastomoses indicates the inverted tissue remains soft and pliable as opposed to the inverted cuffs containing catgut, which are rigid.[3] It is possible that the reaction to catgut found in experimental anastomoses, and not found to such an extent by Mall, by Sabin, and by Scarff in silk anastomoses, accounts for both the delayed mucosal healing and the more prolonged ileus in the catgut anastomoses. It seems inescapable that it contributes to the persistence of the inverted ridge at the suture line.

A final factor in favor of this procedure is that it possesses neatness and simplicity, and freedom from complicated or risky manipulations. It is best for the surgeon to familiarize himself with the method in the dog before applying it to human patients.

SUMMARY

1. Between November 1, 1940, and March 1, 1947, eight resections have been done in caring for intussusceptions at the University of Minnesota Hospitals. One had exteriorization and delayed closure, and seven had primary, aseptic anastomosis. All patients recovered.

2. The indications for resection were:

Infarction of intussusceptum	5 cases
Recurrent intussusception with polypoid Peyer's patch	1 case
Developing recurrence while observing for viability, and Meckel's diverticulum	1 case
Irreducible intussusception due to a large polyp	1 case

3. The choice of procedure lies between exteriorization and early closure on the one hand, and resection and primary closed anastomosis on the other. With a background of closed anastomoses, the latter course is preferred here.

4. A simple, safe type of one-layer silk, closed anastomosis is presented.

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MEDIASTINAL ABERRANT GOITER*

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PARTIALLY INTRATHORACIC GOITERS are very common, especially in the endemic goiter areas (10 to 15% of all cases[7, 13, 17, 19, 25, 33]) and aberrant thyroid tissue not infrequently has been encountered in the neck, but aberrant intrathoracic goiters are very rare. A review of the medical literature in the English language for the past ten years reveals only 14 unquestionable cases, including six collected from the European literature by Mora, Isaacs, *et al.*[25]

Crile,[6] Smith,[28] and Touroff[30] and others have reported multiple papillary carcinomatous masses in the thorax that may have developed from aberrant thyroid tissue but may well have been metastases rather than primary tumors, so they are not included in the table.

It is extremely probable that aberrant thyroid tissue is much more common than these reports indicate, for not one report of normal thyroid tissue in this area was found. All except the cases of carcinoma showed the pathology of nodular goiter, either toxic or non-toxic, and a majority were associated with nodular goiters in the neck. This parallels closely the pathology of partially substernal goiters which always result from the growth of large nodular glands in the neck.

It is noteworthy that several authors[6, 19, 33] report huge numbers of goiters without a single aberrant mass in the thorax and that more than one leading authority[19, 31] has expressed doubt as to the existence of this anomaly.

Blades,[2] in his report of 109 cases of mediastinal tumors in the Army of the United States, mentions only two of thyroid origin. These cases were not included in the table because of insufficient data. The fact that almost if not all of these tumors were in males is probably a factor in his series.

CLASSIFICATION

The lack of a standard classification for intrathoracic tumors of thyroid origin makes it difficult to be sure of one's ground in a study of the literature, and some case reports may have been missed for this reason. I would like to suggest a classification that, while it is somewhat clumsy, is at least free from ambiguity. It is not original except in so far as sharpness of definition is involved.

INTRATHORACIC GOITER

I. Aberrant Mediastinal Goiter.
II. Substernal Goiter.

* Read before the Meeting of the American Surgical Association, March 25–27, 1947, Hot Springs, Va.

A. Complete.
B. Partial.
   1. Intermittent.
   2. Constant.
      a. First degree (less than one-half).
      b. Second degree (more than one-half).

TABLE I

Author	Location	Attachment	Blood Supply	Approach	No. Cases
Mora[23] et al.	Posterior superior mediastinum	Not definitely stated; probably to left lobe of thyroid	From neck; origin not definitely stated	Cervical	1
The Berards[1]	Retro-esophageal	Not stated	Not stated	Cervical	1
Von Haberer[33]	Multiple masses in chain to posterior mediastinum	Left lobe of thyroid	Not stated	Trans-sternal	1
Roholm[28]	Retro-esophageal	Unknown	Unknown	No operation; aspiration biopsy	1
Urban[31]	Retro-mediastinal	Not stated	Not stated	Cervical	2
Henschen[12]	Retro-esophageal	Thin process to cervical goiter	Not stated	Not stated	1
Hicken[13]	"Deeper portion of chest cavity"	None to thyroid gland	Not stated; not from neck	Discovered at autopsy	1
Hollenberg[14]	Anterior mediastinum	Fibrous band to neck	From neck; probably inferior thyroid	Cervical	1
Eggers[9]	Anterior mediastinum	None to neck	Not stated	Trans-sternal	1
deCourcy[7] and Price	Anterior mediastinum	Fibrous band to trachea in neck	Not identified; not from neck	Trans-sternal	1
Mason[21]	Right posterior mediastinum	No cervical attachment	Not identified	Posterior extrapleural mediastinotomy	1
Cabot case[3] 22352	Right mediastinum on diaphragm	Vascular pedicle upward	From above; source not identified	Posterolateral transpleural mediastinotomy	1
Soley[29]	Right mediastinum touching diaphragm	Vascular pedicle to neck	From neck; source not identified	Autopsy	1
Author	Anterior superior mediastinum	None in neck	From mediastinum; probably thyroid ima.	Cervical	1
Author	Anterior superior mediastinum	None in neck	From mediastinal vessels; aorta probable source	Anterior transpleural mediastinotomy	1
Author	Retro-esophageal	Vascular pedicle posterior to subclavian	From above, probably from subclavian artery	Posterior transpleural mediastinotomy	1

I. *Aberrant Mediastinal goiter* should include all thyroid tumors that lie entirely below a plane extending from the superior surface of the first thoracic vertebra to the suprasternal notch; that are either entirely unconnected with

the thyroid gland proper or are at most connected by a fibrous band. If connected by such a band, they should lie in such a position that the mechanism of Lahey[19] can not conceivably have displaced them to that position from the neck (for example, the case of Churchill[3] that rested on the right leaf of the diaphragm).

The contention that any mass connected with the thyroid gland in any way must necessarily have been forced downward from the neck is unsound. It is reasonable to suppose that masses that descend into the chest during fetal life may retain a connection to the parent gland. However, it must be admitted that if a definite attachment is found and the tumor lies in such a position that it might have been forced down from the neck, there is serious doubt as to its origin. Such cases must be considered questionable. It does not seem reasonable to assume that a mediastinal goiter resting on the diaphragm was displaced from the cervical region to its final position by mechanical means simply because its vascular pedicle extended upward. A mass of aberrant tissue may continue to descend after its vascular connections have been established, just as the thyroid gland itself does after picking up the superior thyroid artery.

II. A. *Substernal goiter, complete,* should include only those uncommon cases in which the entire thyroid gland lies within the thorax. The term is frequently used to include thyroids that lie almost entirely in the mediastinum and on this basis it is reported that about 1% of all nodular goiters are in this class. It is probable that completely intra-thoracic glands are actually quite rare.

II. B. 1. *Substernal goiter, partial intermittent,* should include the "plunging goiters" that slip into and out of the chest cavity during the act of swallowing or during changes in position of the neck.

II. B. 2. *Substernal goiter, partial constant,* first and second degree, require no explanation. Many of those spoken of as completely substernal probably belong in this group.

Since the term "substernal goiter" is in common use for glands partially displaced into the mediastinum and since practically all such tumors lie in a substernal position, it seems logical to reserve this term for such cases. On the other hand, since aberrant thyroid tissue may lie anywhere in the mediastinum, the broader term mediastinal seems more appropriate.

CLINICAL SIGNIFICANCE

A sharp separation of aberrant tumors from those mechanically displaced into the chest is important not only on purely scientific grounds but also for clinical reasons. Substernal goiters, having been displaced from the neck into the mediastinum by the mechanism so graphically described by Lahey,[19] almost, if not always, lie in the anterior compartment of the superior mediastinum in front of the trachea, the great vessels and the recurrent nerves, and are directly connected to or continuous with the thyroid gland proper. They almost if not always derive their blood supply from the inferior thyroid

vessels. Therefore, if those vessels are secured, the substernal mass or masses can safely be displaced into the neck by traction, blunt dissection, coughing (by the patient), or by any combination of these three, after which they can be removed without great difficulty, and without undue danger of hemorrhage or of injury to the recurrent nerves. If such a mass is too large to permit its delivery intact, it can be eviscerated by Lahey's method, after which it can be delivered and removed as a smaller mass would be.

The safety of the above mentioned procedures depends upon the anatomic relations previously described, and especially upon the fact that the blood supply of the tumor is accessible from the neck. In view of the fact that the thyroid anlage originates at what will become the base of the tongue and descends anterior to the larynx and trachea, it seems highly probable that most aberrant thyroid tissue will be found in the same location and with the same blood supply as the substernal portion of a substernal goiter. Under these circumstances, the mass can and should be removed by the same methods. In fact, it seems probable that many aberrant thyroid masses have been so removed without special comment by the operator.

If, however, the mass does not lie in the classical location; if it does not have the usual relation to the great vessels, the trachea, the esophagus, and the recurrent nerves; if it does not receive its blood supply from vessels accessible from the neck; any attempt to remove it by the usual technic may be unsuccessful or disastrous.

I have had what appears to be the unusual experience of encountering three aberrant mediastinal goiters that illustrated most of the problems that may arise.

CASE HISTORIES

Case 1.—Mrs. M. K., white female, age 50 years, was admitted to Touro Infirmary April 5, 1939. She complained of a large cervical goiter of two years' duration and of dysphagia that has become progressively worse for one year. There was no dypsnea. There were no signs nor symptoms of thyrotoxicosis.

Physical examination showed nothing of note except a large nodular goiter, the isthmus of which extended below the supra-sternal notch. Both vocal cords moved freely.

X-ray examination showed "a wedge-shaped widening of the superior mediastinal shadow, which is associated with a dextro displacement of the trachea suggesting a substernal extension of an enlarged thyroid." Unfortunately, these x-ray films have been lost.

Routine laboratory examinations showed nothing of significance.

Operation, April 28, 1939. Under ethylene anesthesia (not intratracheal) the usual collar incision was made, the infra hyoid muscles divided, and a subtotal resection of the right lobe and a total removal of the isthmus and left lobe of the thyroid were carried out. Two substernal masses entirely separate from the cervical goiter were found. One lay behind the right sterno-clavicular joint and a larger one was directly behind the sternum. Both were freely movable and were delivered into the neck by gentle traction. There was no bleeding. The mass on the right had a long vascular pedicle that extended into the mediastinum. The centrally located mass had no organized vascular pedicle. Neither received its blood supply from the inferior thyroid vessels.

The operative field was dry and exposure was excellent at all times, in spite of which bilateral vocal cord paralysis occurred. Dyspnea became progressively worse and on the

following morning tracheotomy became necessary. Fortunately, no wound infection resulted, and she was discharged on the 15th postoperative day, in excellent condition except for the vocal cord paralysis.

Pathologic report.—The two substernal masses measured 6 x 5 x 3 cm. and 4 x 2 x 2 cm. respectively.

Diagnosis.—Nodular nontoxic goiter with cystic change and some calcification.*

Comment.—In this instance there were two separate masses in the anterior compartment of the superior mediastinum, entirely unconnected with the thyroid gland proper, and deriving their blood supply from some mediastinal vessel or vessels, perhaps a thyroid ima. Both tumors were easily displaced into the neck and removed in a dry field with the blood supply under visual control, so no danger of hemorrhage existed, but in spite of this satisfactory exposure both recurrent nerves were permanently damaged or severed. Since they were not dissected out, I cannot be sure how or where they were injured, but in view of the excellent exposure and the very dry field at all stages of the operation, I am quite certain that the nerves were not cut or ligated at any point in their usual courses. It is an interesting fact that the first signs of respiratory distress occurred 15 minutes after the resection had been completed. I suspect that these tumors lay between the nerves, and that they were stretched or torn during the delivery of the masses into the neck. Probably one cannot fully depend upon the often-repeated statement that the recurrent nerves always lie behind substernal goiters, and should in such cases expose them as Lahey has urged in all thyroidectomies.

Case 2.—E. W., colored female, age 45, was admitted to Charity Hospital on April 3, 1945, complaining of shortness of breath when lying down and on exertion. Nausea frequently followed the dyspnea. She also complained of sweating, nervousness, palpitation, and swelling of the ankles.

In September, 1940, she had had a subtotal thyroidectomy performed by me for a huge calcified nontoxic nodular goiter. A similar mass was recognized in the chest, and diagnosed substernal goiter (Fig. 1), but at operation no connection with the thyroid gland nor its blood supply could be found. No attempt was made to remove it from above because of its huge size and the uncertainty as to its blood supply. The patient declined further surgery and was not seen again by us until the above date. She was, however, observed intermittently in the medical clinic.

On this admission examination showed blood pressure 170/100, pulse 120, respiration 28. The chest showed physical signs of a large mass in the anterior superior mediastinum and of fluid in the left pleural cavity. The heart was markedly enlarged and a soft systolic murmur was heard at the apex. The liver was enlarged and tender and the spleen was palpable. X-ray examination showed the large partially calcified substernal mass practically unchanged since the first operation.

The E. K. G. showed definite evidence of myocardial disease.

The medical department made a diagnosis of congestive heart failure complicated by a large mediastinal tumor, probably of thyroid origin. Engorgement of the neck veins and increased venous pressure were considered to be due to cardiac failure rather than to the tumor. Under bed rest and medical treatment the cardiac condition improved markedly, but finally a point was reached at which it was believed no further improvement could be expected without removal of the tumor which pressed upon the heart and great vessels.

X-ray examination at this time showed a huge mass in the anterior compartment of the mediastinum (Figs. 2 and 3). It extended from the supra-sternal notch to the 5th rib anteriorly and occupied one half the transverse diameter of the chest cavity, being slightly more prominent on the left side. The trachea was displaced moderately to the right.

* At a later date Brien King's operation was performed and the laryngeal obstruction relieved.

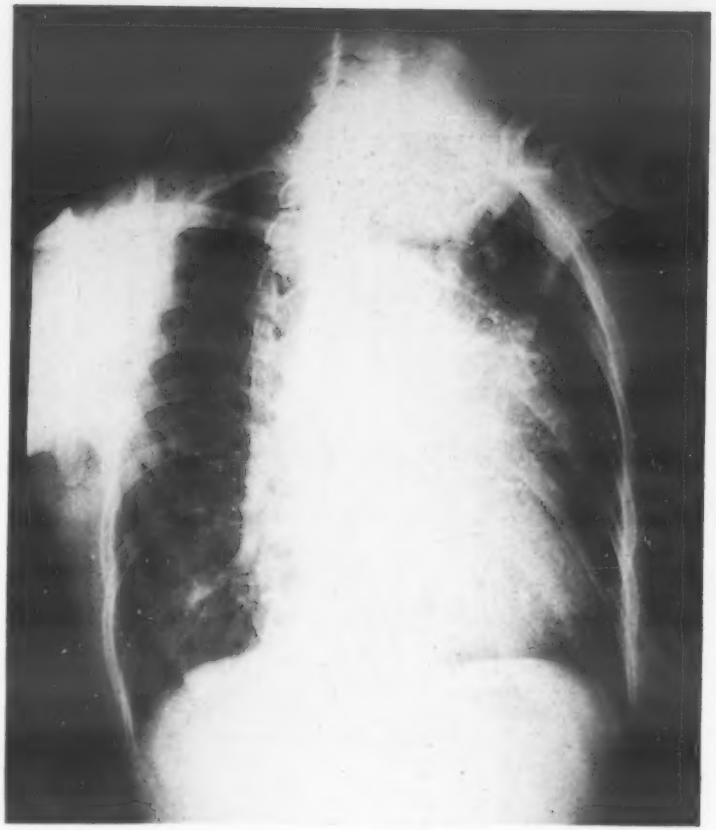

FIG. 1.—Case 2: Roentgenogram showing huge calcified cervical goiter and similar mass in mediastinum.

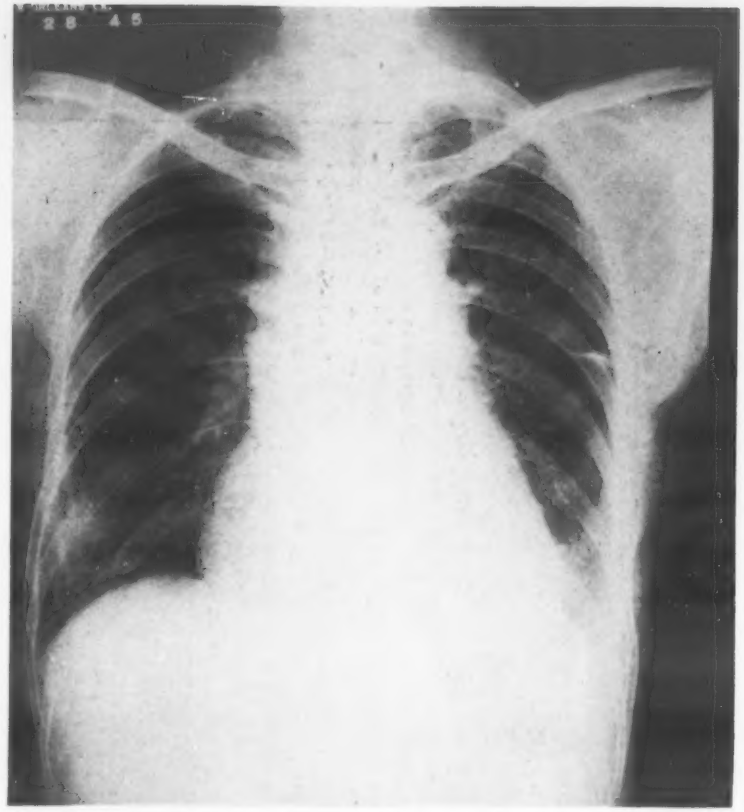

FIG. 2. — Case 2: Roentgenograms after cervical thyroidectomy, showing large calcified mass in anterior-superior mediastinum with displacement of trachea to the right.

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Operation, April 25, 1945. Anesthesia: Intratracheal ethylene-ether. An anterior approach was made through the 2nd interspace with division of the 2nd and 3rd costal cartilages. The tumor bulged far into the left hemithorax and was covered only by the pleura, which was freely incised anterior to the phrenic nerve. By combined blunt and sharp dissection, the mass was freed from its bed and delivered into the left chest cavity.

FIG. 3. — Case 2: Roentgenograms after cervical thyroidectomy, showing large calcified mass in anterior-superior mediastinum with displacement of trachea to the right.

This dissection was tedious because of numerous strong fibrous attachments but was not unduly difficult because of the excellent exposure. In order to expose the right side of the tumor the sternum was divided transversely shortly before the completion of the dissection. One large artery entered the mass on its posterior aspect about 3 or 4 cm. below the concavity of the arch of the aorta.

A large mediastinal cavity remained, so the mediastinal pleura, now redundant, was attached to the anterior chest wall so that the costal pleura could be completely closed,

while leaving a small opening into the mediastinal cavity, which was loosely packed with dry gauze. The pleural cavity was closed without drainage. The mediastinal pack was removed in 48 hours but a slight hemorrhage occurred on the following day, so it was replaced for 48 hours more. Moderate drainage but no active infection persisted for ten days, after which her convalescence was uneventful. The cardiac status improved considerably, but not completely, and her activities are still somewhat restricted, but failure has not recurred (Fig. 4).

Pathologic report.—A nodular tumor weighing 426 Gm. and measuring 15 x 10 x 5 cm.

Diagnosis.—Fetal adenoma with fibrosis, calcification, hemorrhage, and cyst formation.

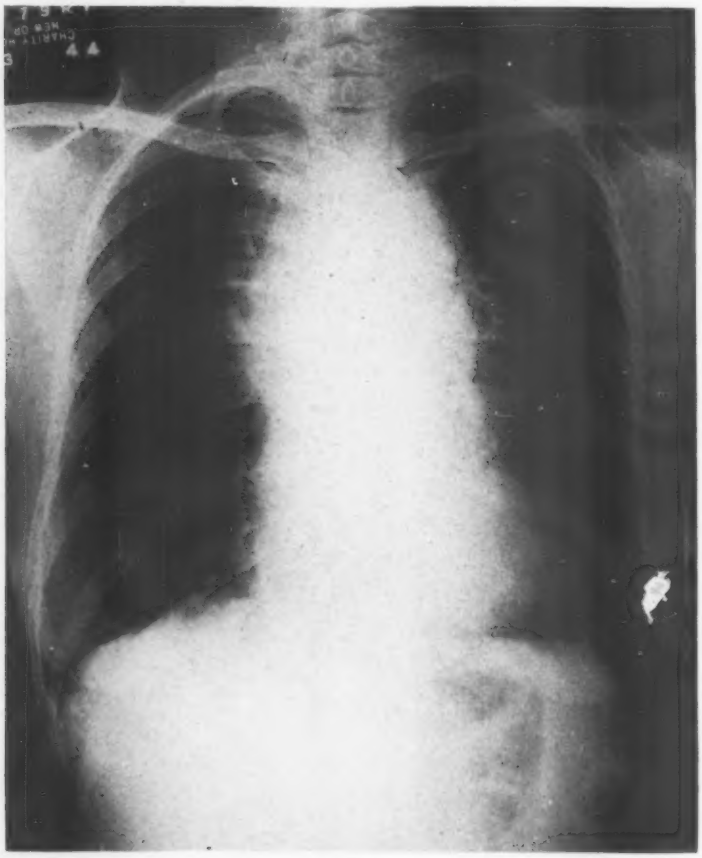

FIG. 4.—Case 2: Roentgenogram after removal of intrathoracic goiter.

Comment.—In this case there was a single very large mass in the anterior compartment of the mediastinum extending well below the arch of the aorta. Its location and anatomic relations were exactly those of a large substernal goiter, but it was entirely unconnected with the thyroid gland proper and did not receive its blood supply from a cervical vessel. It was supplied by a single large artery that entered its left posterior aspect well below the aortic arch, from which it probably arose.

Any attempt to remove this mass through a cervical incision would, in my opinion, have been either unsuccessful or fatal, or both. On the other hand, the anterior transpleural approach employed provided free exposure at all times, all points of attachment being divided under direct vision.

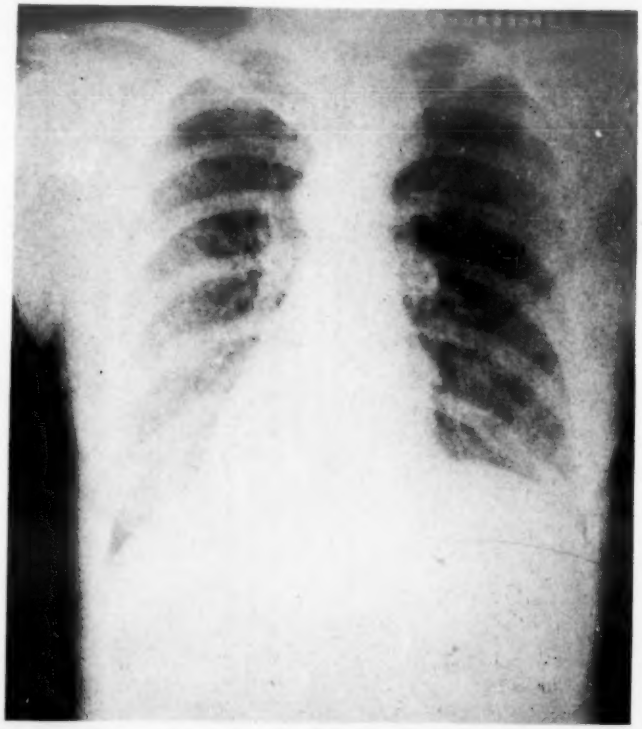

FIG. 5.—Case 3: Roentgenogram showing mediastinal mass projecting into the right lung field remaining after thyroidectomy.

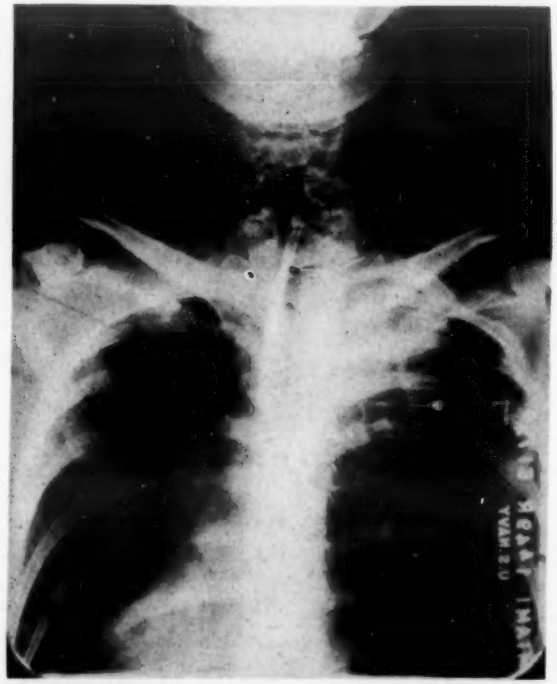

FIG. 6.—Case 3: Roentgenograms with visualization of esophagus, showing the increased size of the mediastinal mass and the fact that it causes displacement of the esophagus anteriorly and to the left.

Case 3.—Mrs. M. C., white female, age 42 years, was admitted to Touro Infirmary on June 25, 1944, complaining of a tumor in the chest.

In May, 1933, a subtotal thyroidectomy had been performed for a mildly toxic nodular goiter. A diagnosis of intrathoracic goiter was made at that time, but at operation the intrathoracic mass could not be located from the cervical incision (Fig. 5).

She had been in excellent health since this operation, and the intrathoracic mass produced no symptoms, but repeated x-ray observation showed that it was steadily

FIG. 7.—Case 3: Roentgenograms with visualization of esophagus, showing the increased size of the mediastinal mass and the fact that it causes displacement of the esophagus anteriorly and to the left.

increasing in size. The last roentgenogram revealed a large, roughly spherical mass posterior and to the right of the esophagus and projecting well into the right lung field (Figs. 6 and 7) opposite the 1st to the 6th thoracic vertebral bodies.

Physical examination showed nothing of note. Both vocal cords moved freely. The electrocardiogram was negative. Hematology showed a mild secondary anemia.

Operation, June 27, 1944. Anesthesia: Intratracheal cyclopropane. A posterior transpleural approach, with resection of the 4th and division of the 3rd and 5th ribs, was made. Exposure was excellent. The tumor was seen to project well into the apex of the right pleural cavity and to lie directly upon the bodies of the vertebrae. It was covered laterally only by the pleura, which was incised posterior to the phrenic nerve. The tumor was easily shelled out and had only one firm attachment, its vascular pedicle, which descended

behind the subclavian artery to the upper pole of the mass. This pedicle was ligated and divided. The rent in the mediastinal pleura was sutured and the chest cavity closed without drainage.

The postoperative course was uneventful and she was discharged on the 12th postoperative day.

Pathologic report.—"A tumor weighing 212 Gm. . . . roughly ovoid in shape . . . approximately 12 x 9 cm."

Diagnosis.—"Adenoma of aberrant thyroid tissue." (Fig. 8.)

Comment.—This case shows a complete deviation from the normal in the descent of thyroid tissue into the thorax. The tumor lay in the posterior compartment of the

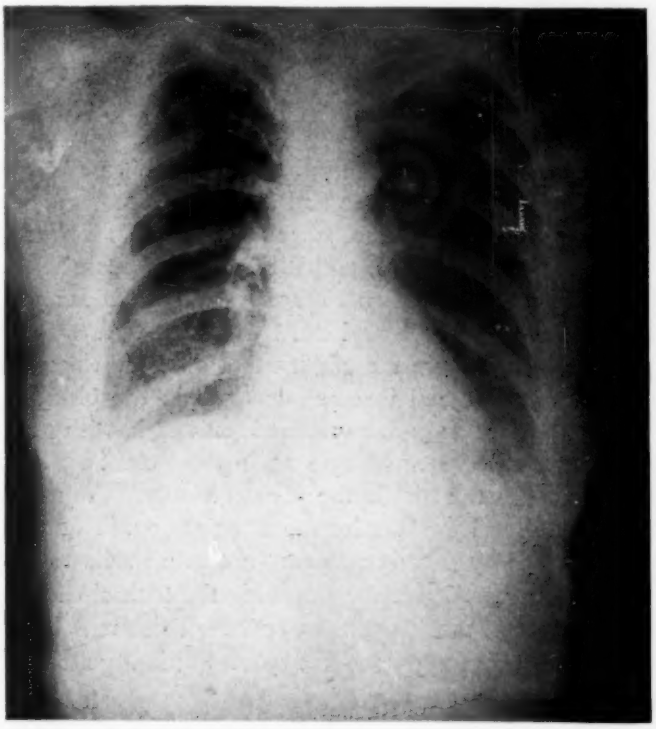

FIG. 8.—Case 3: Roentgenogram after removal of mediastinal aberrant goiter.

mediastinum, behind and to the right of both trachea and esophagus. It probably derived its blood supply from a branch of the subclavian artery, but this artery descended behind the subclavian trunk. Mediastinal thyroid masses have been removed from similar locations through cervical incisions, when a band of fascia connected them to the cervical gland, but if the blood supply cannot be secured before delivering the mass, it is a very dangerous procedure. In this instance the vessels would almost certainly have been avulsed and would then have retreated behind the subclavian artery, a most disconcerting situation.

OPERATIVE PROCEDURES

Anesthesia. I believe that general inhalation anesthesia, administered through a semi-rigid intratracheal tube, is preferable for all substernal or

mediastinal goiters. Several authors of wide experience have recommended local anesthesia chiefly because the patient can cough and help in the delivery of the substernal mass, but a skilled anesthetist can lighten the anesthesia and get the same effect at will, and the assurance of a clear airway at all times during manipulation about a displaced and distorted trachea is of paramount importance. It is also highly desirable to be able to inflate the lung or lungs if the pleural cavity should be opened.

Approach. Mediastinal goiters, aberrant or otherwise, that lie in the anterior compartment of the mediastinum and derive their blood supply from vessels that are accessible from the neck should undoubtedly be removed by the cervical approach even if they should be so large that evisceration is necessary before delivery can be affected. If, however, the blood supply cannot be identified and controlled from above, any attempt to remove the mass by this route may be disastrous.

Splitting the sternum to expose large substernal tumors has been tried by many surgeons, but both failures and fatalities have been numerous.[6, 7, 8] This approach gives a poor exposure since the opening is limited by the shortness and rigidity of the first ribs, and the bony margins of the opening are completely inflexible. The substernal space is very vascular and hemorrhage, usually venous, may be severe and hard to control. The pleural cavities approach each other closely in the midline and often overlap, so one or both are frequently opened. Small inaccessible tears in the pleura are likely to result in tension pneumothorax, because air is sucked in with each inspiration, whereas in expiration the pleura bulges against the chest wall and closes the opening, thus trapping the air in the pleural cavity. Any attempt by the anesthetist to inflate the lung fails for the same reason. I have observed one operative death caused by this mechanism (not in a mediastinotomy), which incidentally can be easily corrected by opening the pleural cavity widely, and thus permitting escape of the trapped air. It is for these reasons among others that I prefer a transpleural approach to any mediastinal goiter that cannot be removed solely by the cervical route.

Almost all mediastinal tumors tend to expand into one or the other lung field since that is the direction of least resistance. The approach may be made from that side, anteriorly or posteriorly as the location of the mass dictates. The size and location of the tumor will determine whether or not rib resection is required. In general very large tumors and high posterior approaches require rib resection, whereas small tumors and low or anterior approaches do not.

When a wide transpleural opening is made, more than half of the tumor is usually clearly visible, together with the heart and great vessels and the phrenic and vagus nerves. With this free exposure the dissection can be planned with almost all important structures in full view. As compared with the extra pleural approach, the dissection required is almost 50 per cent less and the visibility almost infinitely better.

CONCLUSIONS

1. The classifications of intrathoracic goiters in common use are variable and confusing. A method of classification is proposed.

2. Aberrant mediastinal goiters are rare. Fourteen cases have been collected from the English medical literature of the past ten years. This number includes six cases from the European literature collected by Mora et al.[25] Three cases are added.

3. The cervical approach is preferable for all intrathoracic goiters located in the anterior compartment of the mediastinum and receiving their blood supply from vessels accessible from the neck, but a transpleural approach is desirable for all others.

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STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC., REQUIRED BY THE ACTS OF CONGRESS OF AUGUST 24, 1912, AND MARCH 3, 1933
Of ANNALS OF SURGERY, published monthly at Philadelphia, Pa., as of November 1, 1947.

State of Pennsylvania } ss.
County of Philadelphia }

Before me, a Notary Public in and for the State and county aforesaid, personally appeared J. R. Arnold, who, having been duly sworn according to law, deposes and says that he is the Treasurer of the ANNALS OF SURGERY and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management (and if a daily paper, the circulation), etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, as amended by the Act of March 3, 1933, embodied in section 537, Postal Laws and Regulations, printed on the reverse of this form, to wit:

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[Signed] J. R. ARNOLD.

Affirmed to and subscribed before me this 19th day of September, 1947.
[Seal] HARRY J. BEARD.
(My commission expires March 5, 1949.)

INFLAMMATORY OBLITERATION OF THE COMMON AND HEPATIC DUCTS FOLLOWING CHOLECYSTECTOMY*

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A. B., A WOMAN 41 YEARS OLD, has had 5 children. When first seen on February 18, 1942, she gave a history of attacks of severe epigastric pain that had commenced four years ago, one month after parturition. Recently the acute attacks had ceased but had been replaced by a burning sensation in the right upper quadrant of the abdomen. There was no history of jaundice or clay-colored stools.

Examination showed tenderness over the gall bladder and appendix. An X-ray showed stones in the gallbladder. On March 25, 1942, a cholecystectomy and appendectomy were performed under ether anesthesia at the Methodist Hospital. A soft rubber tube drain was inserted beneath the liver. The gallbladder was large and full of numerous stones. The operation was an easy one and took one hour and 15 minutes. The pathologic report showed atrophy of the mucosa of the gallbladder, slight thickening of the wall and infiltration with a few round cells. The diagnosis was chronic cholecystitis and cholelithiasis.

Following operation there was occasional vomiting for 36 hours. The dressing was stained with a little biliary discharge. Two days after operation the sclerae were clear but the skin was a little muddy. On the third day there was slight jaundice present. On the fourth day she had two yellow and brown fluid evacuations. There was a little pleurisy in the left lower chest. On the fifth day tan colored formed feces were obtained. There was still a little biliary discharge on the dressing. On the sixth day the icteric index was 30 and the leucocytes were 10,900 with 80 per cent polynuclears. A small amount of light yellow feces was evacuated at 2 P.M. but at 9:40 P.M. the first clay-colored stool was obtained, *i.e.*, six and a half days after operation. From this time on the jaundice and clay-colored stools persisted.

At the request of the husband, Dr. Thomas M. Brennan, an attending surgeon to two large Brooklyn hospitals, then saw her in consultation. It was evident that an obstructive jaundice was present and a second operation was performed on April 5, 1946, the 11th day after the original operation. Doctor Brennan was present at the operating table as an observer and Dr. Pierre A. Renaud, an attending surgeon to the Methodist Hospital, was first assistant. An incision was made through the old scar beneath the ribs on the right side and extending one inch further laterally. Adhesions were separated with difficulty, exposing the region of the common duct and Foramen of Winslow. No accumulation of bile was found. The entire edge of the Gastrohepatic

* Read before the Meeting of the American Surgical Association, March 25–27, 1947. Hot Springs, Va.

omentum was thickened to about an inch in diameter from the fissure in the liver to the duodenum. After careful dissection and aspiration with a needle and syringe it was impossible to locate the position of the common duct. Attempts with a thumb forceps finally secured a free flow of bile, probably from the left hepatic duct as a probe could be passed upward and to the left but could not be passed downward into the common duct or upward to the right. As the operation had been prolonged and the condition of the patient was uncertain a small catheter was passed into the duct and fastened and the abdominal wall closed around a larger tube. The time of this operation was one hour and 45 minutes. No evidence was found that the common duct had been clamped, tied or cut or injured in any way at the first operation. Doctors Brennan and Renaud concurred in this opinion.

Following this second operation the jaundice finally cleared up, although the stools remained acholic. The patient was discharged from the hospital on May 2, 1942, with a tube and persistent biliary fistula. From July 1942 to April 1943 three further operations were performed by a surgeon in another city. The last one was a suture of the distal end of the common duct (exposed behind the duodenum) to a biliary duct in the fissure of the liver over a T tube. There was no evidence of any proximal portion of the common duct or of either hepatic duct.

Still later another operation was performed by a different surgeon who drew the duodenum up and performed an anastomosis in the fissure of the liver with some improvement on latest repo Such an experience as this is a tragic one for both patient and surgeon.

Although there are many references in the literature to "inflammatory stricture" most of them are brief and the condition is not well understood by internists or surgeons who are still prone to believe that all jaundice that follows operation and persists is due to an error in technic. Miller[1] states the situation well as follows, "Although the so-called diffuse stricture due to fibrosis of the wall of the common duct is not common, nevertheless, sufficient evidence is now at hand to warrant its recognition as well as indicate that it is a condition quite apart from congenital or traumatic stricture and probably quite different in mode of production from the strictures caused by gallstones. There seems good reason to consider it an inflammatory lesion which results in an essential fibrosis of the wall of the common duct. Neither traumatism or gallstones appear to be a factor in its causation."

Judd[2] believed that "Obliterative cholangitis resulting in stenosis of the common or hepatic duct is the cause of a considerable proportion of strictures of the common duct that have been classified as traumatic." He found that "in 16 out of 64 operations for stricture the condition was the result of obliterative cholangitis and in 15 more it might have been." Carter[3] discusses the "benign" type of cicatricial stenosis at length citing illustrative cases.

Dr. John A. Timm, in a personal communication, reports a 30-year-old Puerto Rican who had no previous operation. He was markedly jaundiced. At operation Doctor Timm found sclerosis of the common, part of the cystic

and hepatic ducts with inflammatory induration of the omentum containing the portal structures. The pathologic conditions present were the same as in our case at the second operation. Walters[4] speaks of inflammatory stricture of the common ducts. He mentions one case in which there was a 15-year interval between cholecystectomy and the onset of obstructive symptoms. In his article for Lewis's Practice of Surgery[5] he says, "Occasionally the obliteration of the duct is due to an inflammatory process which destroys the mucosa lining the duct and converts it into a fibrous cord." Whipple[6] in Nelson's Loose Leaf Surgery speaks of "Stenosis of the ducts following trauma or inflammation." Lahey[7] also has seen "One case of complete obliteration of the bile duct undoubtedly due to an inflammatory process which completely destroyed the mucosa within the common and hepatic ducts converting that structure into a fibrous cord without a lumen." He says that for practical purposes nearly all the strictures of the common and hepatic ducts are man-made and reports a series of nine such strictures. It is interesting to note that he mentions the fact that the end of the duct proximal to the stricture was dilated in seven of the nine cases and, in the other two cases, he does not mention whether it was dilated or not. As most of the inflammatory strictures, like our case, show no dilatation above and an actual obliteration, even into the liver fissure, this seems an important differential point.

SUMMARY

Following an easy cholecystectomy there was evidence of obstructive jaundice. A second operation revealed an extensive cellulitis of the gastrohepatic omentum but no evidence of injury at the first operation. The cellulitis eventually terminated in a complete obliteration of some inches of the common and hepatic ducts. The absence of dilatation of the proximal portion of the duct is mentioned as a point in differential diagnosis.

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THE APPENDICEAL STUMP*

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IN THE TREATMENT OF ACUTE APPENDICITIS, there is apparently complete agreement that early operation is the only safe therapy. However, in relationship to the appendiceal stump, considerable variance of opinion exists regarding the proper operative technic.

Although the first appendectomy was performed as early as 1884, no general agreement exists regarding the preferable technic for management of the appendiceal stump. Authors in general do not seem satisfied with any specified method, but advocate their own particular technic because of end results. William Mayo, in explaining his preference for the technic he employed, summarized by saying, "I have not had occasion to regret not having inverted the stump."

Surgeons from various parts of the world, in statistically reporting large series of cases, apparently obtain comparable results. The majority reveal a tendency to advocate their particular method of management of the appendiceal stump, and also demonstrate a willingness to rationalize successful results obtained, as being due to the particular technic employed.

With such close correlation of statistical results and divergence of opinion regarding the manner of obtaining them, various methods of treating the appendiceal stump have been studied in an effort to determine whether or not the argument is academic or factual in character.

A series of rabbits were used for the study. The major interest was directed toward end results rather than interval. All animals were autopsied postoperatively. Gross and micro-pathology studies were made at 48 and 96 hour intervals as well as one week and one month. For purposes of clarity, discussion will be limited primarily to the observations noted at an interval of one month.

The three basic methods generally accepted for treating the appendiceal stump were employed, *e. g.*, (1) simple ligation (the "tie and drop" method); (2) ligation and inversion; (3) inversion without ligation. Each method was subjected to variable technics, with catgut; silk; phenol and cautery. Such variables are unimportant to this discussion, since they simply represent technical variations of accomplishing and demonstrating the underlying principles involved.

The method originally described by Dawbarn in 1895, of invagination of the appendiceal stump into the lumen of the cecum was not employed. In this article, when reference is made to invagination of the stump, the term means into the wall of the cecum and not into the lumen. Common usage

* Read before the Meeting of the American Surgical Association, March 25–27, 1947. Hot Springs, Va.

has given a misconception to the terms—"invagination into the cecum"—and—"into the lumen of the cecum." What is accomplished in the usual technic of invagination, is the introduction of a blind pouch into the wall of the cecum and not into the lumen. This applies whether the stump is, or is not, ligated. Employment of the technic of anatomically true invagination of the stump into the lumen of the cecum involves technical difficulties that immeasurably increase the possibilities of fecal contamination.

The conventional technics now employed are considered simpler and acceptable, and the end clinical results justify their use. The original Dawbarn technic is a more formidable procedure than the standard methods, although in practice, it is more physiologic.

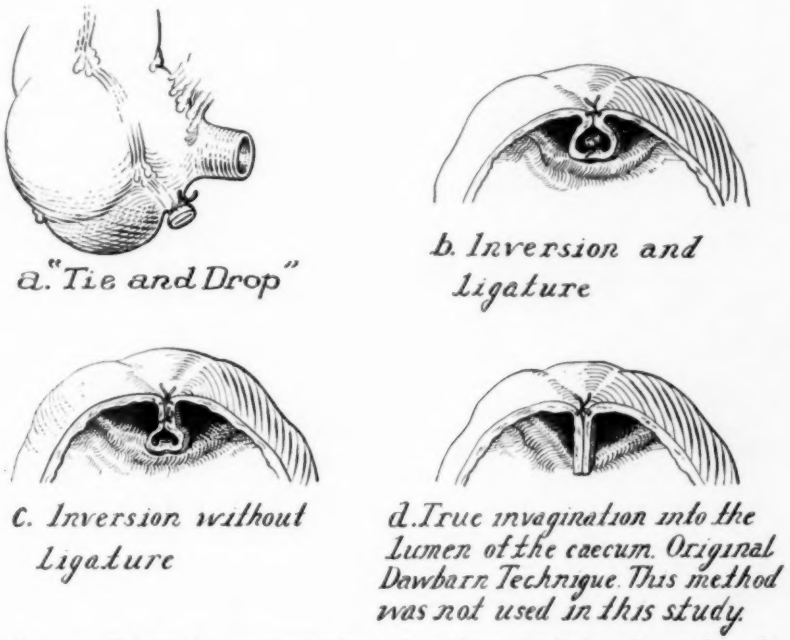
a. "Tie and Drop"
b. Inversion and ligature
c. Inversion without ligature
d. True invagination into the lumen of the caecum. Original Dawbarn Technique. This method was not used in this study.

FIG. 1.—Schematic representation of various methods of treating the appendiceal stump.

Bickham, in describing operative technics, states that the canal of the appendiceal stump is probed to prove its patulousness and that it may be dilated with special forceps to aid invagination. Such technic increases the hazards of fecal contamination.

As pointed out by Dawbarn, to invert the stump into the cecal lumen and for it to drain therein, the stump of the appendix has to be turned completely outside in, or inside out. Physiologic advantages of this procedure are nullified by the increased hazards of contamination and leakage.

Deaver indicated that the important objects in appendectomy were (1) ligature of the base of the appendix; (2) removal without contamination; (3)

hemostasis. He further stated that if it could be accomplished satisfactorily, the stump of the appendix should be inverted.

Ochsner and Lilly, in 1937, reviewed the problem and indicated that inversion of the unligated stump was the method of choice. Their diagrams are illustrative of inversion into the cecal wall, although their terminology with non-ligation suggests an end result similar to the Dawbarn technic. Neither the technic advocated by Ochsner and Lilly, which is simply a slight modification of the Halstead "three clamp" method, nor by Goode and Kregel were employed in this study. Both methods basically, are variations of invagination of the unligated stump into the wall of the cecum. The method of Goode and Kregel has the advantage of invaginating a small amount of stump into the cecal wall thereby minimizing tissue reaction in a closed sac.

FIG. 2.—(Rabbit 3)—Section treated by simple ligation or "Tie and Drop," taken 32 days after operation.

Employment of a Cushing right angle stitch, Lembert stitch, or purse-string suture does not alter the final domicile of the appendiceal stump. If a residue of tissue is grasped by a clamp, pushed down and buried by any suture method, it "sits up" and does not "point down."

Adult rabbits, in preference to dogs, were selected for this study because of greater similarity to human intestinal anatomic characteristics. There were 44 experiments—25 with the buried stump and 19 with simple ligation.

At varying intervals (two days; four days; one week, and one month) the animals were anesthetized and the appendiceal stump examined *in situ* and then removed for microscopic study.

Typical protocols, demonstrative of the three methods are presented. Evidence of inflammation, peritoneal contamination, cecal induration, necrosis and extent of adhesions were studied for comparative purposes. While many of the specimens revealed either one or a combination of these factors, no one method revealed dominant characteristics. It will be noted that the interval specimens in the inverted stump technics, on microscopic examination, revealed a greater degree of inflammatory reaction. Comparative end specimens, however, for all methods, microscopically and macroscopically, revealed little variation.

Rabbit 1. "Tie and drop" (examined at 48 hours). Cecal area completely walled off by small intestine and mesentery. No evidence of peritonitis; no gross hemorrhage.

Laboratory: Gross—Stump not invaginated. Serosa smooth except portion distal to ligature. Ligature firm and intact. *Microscopic*—Section showed marked inflammatory response about serosal and submucosal layers. Several large areas of necrosis with slight hemorrhage into the tissue.

Rabbit 2. "Tie and drop" (examined at 7 days). *Laboratory: Gross*—Stump free and smooth. Cecal area free of adhesions. Serosa clean. *Microscopic*—Slight fibrosis; no inflammation. No necrosis; no hemorrhage.

Rabbit 3. "Tie and drop" (examined at 32 days). Cecal area free of adhesions. Encapsulated area in cecum resembled calcified node. *Laboratory: Gross*—Appendiceal stump completely covered by dense fibrous tissue. On section, stump is firm and fibrosed. *Microscopic*—Moderate fibrosis at margin of stump. Low grade inflammation along margins of stump at site of organization. Necrosis in central portion of stump. No hemorrhage. Reaction in tissues localized, slight.

Rabbit 4. Ligation and Inversion (examined at 48 hours). *Laboratory: Gross*—No adhesions about inverted stump. Serosa clean. Stump feels like hard fibrous nodule. No infection or hemorrhage seen. *Microscopic*—Marked inflammatory reaction with P. M. N. cells. Fibrosis over serosa. No necrosis or hemorrhage. Localized reaction in tissue.

Rabbit 5. Ligation and Inversion (examined at 7 days). *Laboratory: Gross*—Inverted stump covered by fibrous tissue with loops of bowel adherent. *Microscopic*—Extensive fibrosis with marked round cell infiltration. Slight necrosis and slight hemorrhage. Reaction moderate and well localized.

Rabbit 6. Ligation and Inversion (examined at 30 days). *Laboratory: Gross*—Peritoneal surface smooth. *Microscopic*—Moderate fibrosis. No necrosis. No hemorrhage. Slight inflammation.

FIG. 3.—(Rabbit 6)—Section treated by ligation and inversion, taken 30 days after operation.

Rabbit 7. Inversion without Ligation (examined at 48 hours). *Laboratory: Gross*—Stump cleanly invaginated with mesentery adherent to site of invagination. On section, there is an encapsulated hematoma in the stump. *Microscopic*—Marked hemorrhage into the tissue with round cell infiltration along margins and considerable fibrosis with beginning organization. No necrosis seen.

Rabbit 8. Inversion without Ligation (examined at 7 days). *Laboratory: Gross*—Inverted stump covered by fibrous adhesions. No evidence of hemorrhage. Feels like a hard fibrous nodule. *Microscopic*—Marked fibrosis. Slight inflammation. One small area of stump necrotic. No hemorrhage. Slight reaction in tissue.

Rabbit 9. Inversion without Ligation (examined at 30 days). *Laboratory: Gross*—Peritoneal surface smooth. No adhesions. *Microscopic*—Slight fibrosis; no inflammation; no necrosis; no hemorrhage. Slight reaction in tissue.

COMMENT

Emphasis has been placed on end results as determined by 30-day specimens. Interval specimens of inversion of the stump, on microscopic examination revealed hemorrhagic infiltration. Since this phenomena was not noted in unburied stump specimens treated by simple ligation ("tie and drop"

method), it was attributed to trauma associated by insertion of the purse-string suture. The danger of injury to blood vessels during insertion of the inverting purse-string suture was emphasized by Colf in 1926.

Bürkle-de la Camp, in experiments on monkeys; Goode and Kregel on dogs, and Kross on rabbits were able to demonstrate advantages of invagination of the unligated stump.

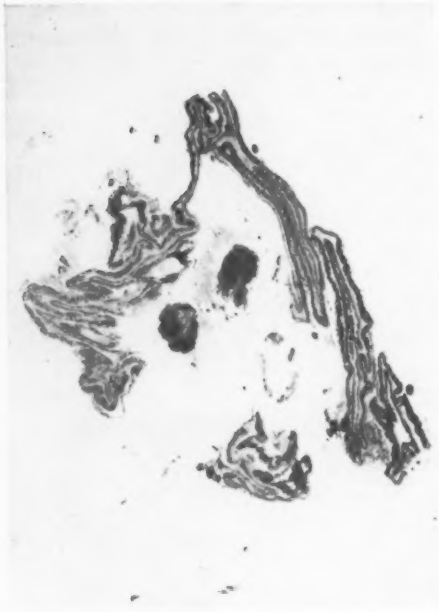

FIG. 4.—(Rabbit 9)—Section treated by inversion without ligation, taken 30 days after operation.

Kross noted mesenteric lymph node enlargement constantly associated with stump inversion, and absence of this change when the stump was left unburied. In this series, no significant variation of lymphatic enlargement was noted.

In this study, many specimens revealed varying degrees of inflammation and necrosis. Encapsulated hematomas were not an infrequent phenomena. No specimen — either buried or unburied—revealed abscess formation—either macroscopically or microscopically.

Microscopically—the interval specimens revealed considerably more inflammatory reaction in the cecum in the buried stump than in the unburied, and more with the ligated buried stump, than when unligated and buried. This latter observation has been noted previously. It is probably due to more adequate drainage by continuity of unligated, crushed, necrotic tissue through the residual lumen of stump, communicating with the lumen of the cecum.

Under pathologic conditions of inflammation associated with appendicitis this type of reaction would probably be much more exaggerated. Anatomic characteristics of the human cecal-appendiceal area offer greater protective advantages from the surgical viewpoint than noted in most experimental animals.

DISCUSSION

1—End results of the standard methods of treatment of the appendiceal stump (a) ligature or "tie and drop" method; (b) inversion into the wall of the cecum of either the ligated or unligated stump, as observed in this study, do not justify claims of the superiority of one method over the other.

2—Interval studies of the two methods revealed no gross discrepancy between the methods but did reveal greater microscopic inflammatory reaction

in the inversion technic. This is probably secondary to trauma from insertion of the purse-string suture.

3—Contamination, hemorrhage and inflammatory reaction would probably be greater with the purse-string suture method than with the simple ligature or "tie and drop" method, under conditions of infection and inflammation.

CONCLUSION

Under controlled laboratory conditions and comparative technic, no superiority of any one method of treatment of the appendiceal stump, as determined by end results, could be demonstrated.

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TALCUM POWDER GRANULOMA: A FREQUENT AND SERIOUS POSTOPERATIVE COMPLICATION*

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THIS STUDY OF TALC GRANULOMA is being presented in order to stress the seriousness and frequency of a known postoperative complication and to suggest a way by which it may be prevented.

During the past 14 years sporadic reports of talcum powder granulomas following surgical operations have appeared in the literature. Because some of these reports have dealt with a small number of cases scattered over a long period of observation, many surgeons and pathologists have tended to consider the problem chiefly as one of academic interest. During the period in which no apparent solution to the fundamental problem was in evidence there perhaps was some excuse for this attitude. Now that alternatives to the use of this dangerous agent in the operating room are available, it is well to realize the variety and seriousness of the complications that may arise from the use of talcum powder on surgical gloves.

This study reviews 37 cases of talcum powder granulomas producing symptoms serious enough to require admission to the Barnes Hospital for treatment. In each instance a previous operation had resulted in the leaving of enough talcum powder in the wound to result in a severe silicotic reaction with consequent serious postoperative complications.

Antopol[1] in 1933 was the first to call attention to the clinical and pathologic significance of Lycopodium and talcum powder granuloma in surgery. He presented 6 cases of granuloma caused by Lycopodium spores and talcum powder crystals introduced into a surgical wound from the surgeon's glove. He pointed out the clinical similarity of these lesions to both neoplasm and to tuberculosis.

Erb[3] in 1935 reported 6 cases of talcum powder granuloma. In 3 of these cases the granuloma was an incidental finding but in the other 3 patients, the talc granuloma was the fundamental cause of the postoperative complaints. One of these cases had a severe talc reaction deep within the brain substance following a neurosurgic procedure.

In 1936, one other case was reported by Owen.[12] A year later Fienberg[4] reported five instances in which talc crystals were discovered in microscopic sections by the use of crossed Nicol prisms. Birefringent material (of which talc is an example) will by this method of examination rotate a beam of polarized light. The latter author reviewed 30,000 cases and states he found

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FIG. 1A

FIG. 1B

FIG. 1A.—Talc granuloma in lumbosacral extradural space following laminectomy. The process is recent and there are numerous giant cells. (H & E × 150).

1B.—Photograph of same field seen in Fig. 1A taken with polarized light to demonstrate the massiveness of contamination. (× 150).

FIG. 2A

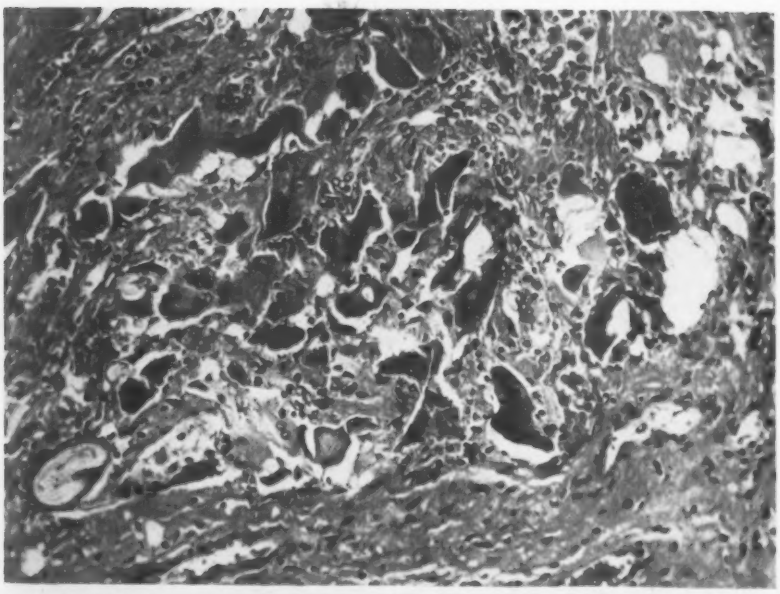
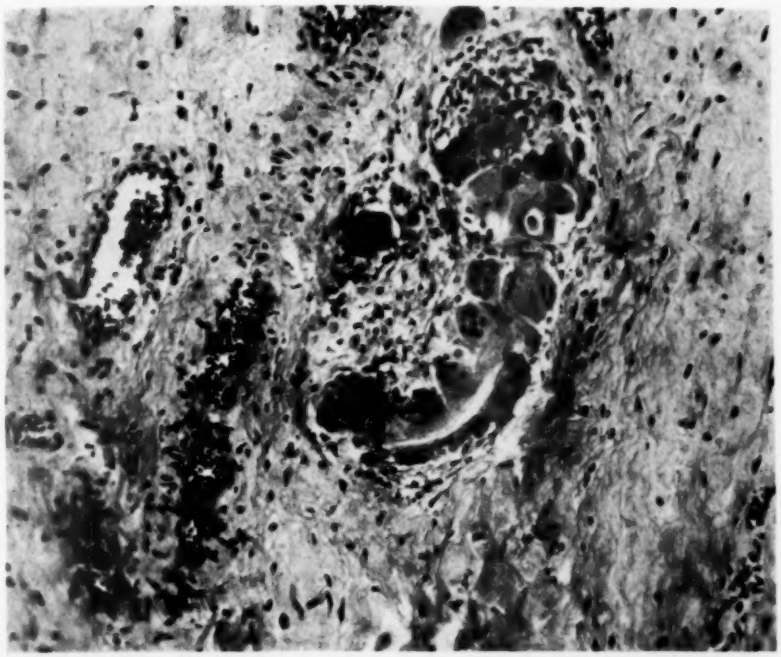


FIG. 2B

FIG. 2A—Active reaction to talc in the wall of the ileum following appendectomy. This had resulted in a persistent fecal fistula. The fibrosis around the giant cells is dense and had extended deep into the intestinal wall, where it was associated with secondary infection. (H & E × 150).

2B.—Photograph of same field seen in Fig. 2A taken with polarized light to demonstrate the birefringent talc. (× 150).

FIG. 3A



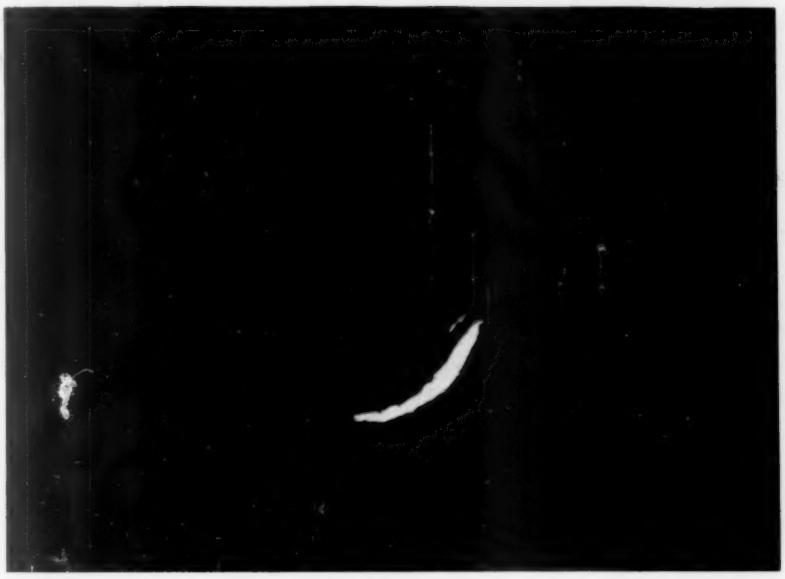
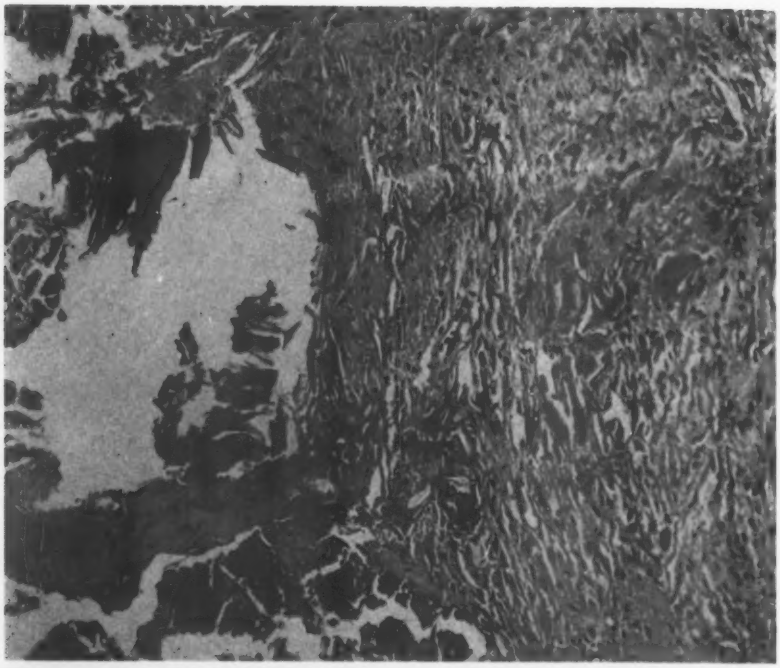


FIG. 3B

FIG. 3A.—Reaction to an unusually large talc crystal. This followed appendectomy, and the resulting lesion was diagnosed roentgenologically and clinically as regional ileitis. There was a diffuse area of edema and fibrosis involving the terminal ileum. (H & E × 150).

3B.—Photograph of same field seen in Fig. 3A taken with polarized light. (× 150).

FIG. 4A



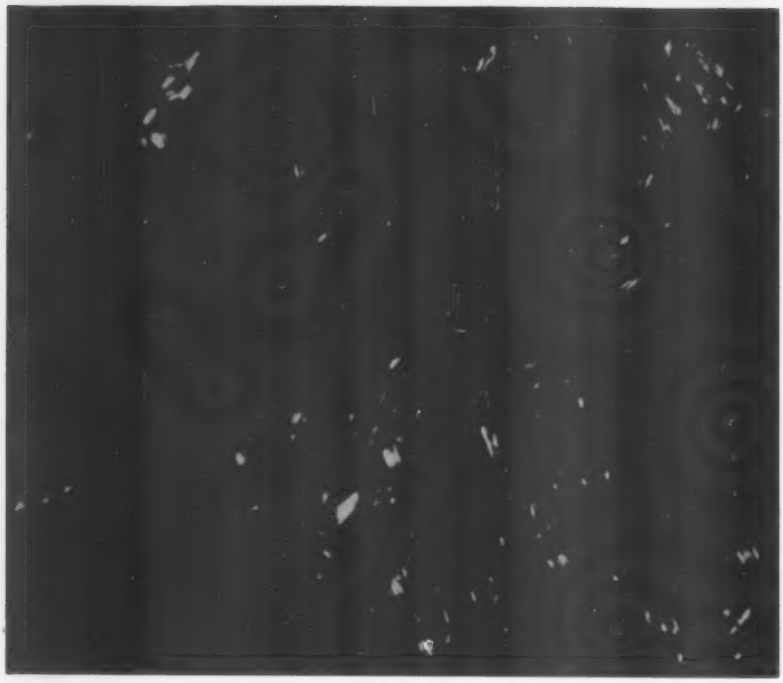


FIG. 4B

FIG. 4A.—Reaction to talc adherent to chromic catgut. This was a peritoneal suture and resulted in the formation of adhesions with subsequent intestinal obstruction. We have noted stenosis of enterostomy stoma as a result of such a reaction to talc contaminating suture material.

FIG. 4B.—Photograph of same field seen in Fig. 4A taken with polarized light to demonstrate widespread contamination with birefringent talc.

but 5 examples of talc granuloma. He reviews, however, only those cases that had been diagnosed as foreign body reaction of an unknown type.

Grieco[7] in Italy reproduced talc granuloma in animals by injecting a fine suspension of talc crystals subcutaneously and intraperitoneally. He demonstrated that only a few crystals were required to incite a large mass of inflammatory reaction.

Ramsey and Douglass[13] in 1940 added 5 cases to the literature and cautioned against the use of talcum powder in the operating room. The same year German[5] noted the similarity between the reaction of the subcutaneous tissue to silica and that of the microscopic picture in sarcoid, pointing out that foreign body granulomas might well be confused with sarcoid.

Ten more cases were added to the literature in 1941 and 1942 when McCormick and Ramsey,[11] Byron and Welch,[2] and Ramsey[14] reported a variety of manifestations of this underlying granulomatous lesion. These authors noted the production of peritoneal granulomas, and of chronic draining sinuses caused by the seeding of talcum powder into the peritoneal cavity during various surgical procedures.

Weed and Groves[21] in an effort to find the mechanism of talcum powder contamination of wounds, studied surgical gloves after their operative use. They found that in 74.4 per cent of all operations at least one of the gloves used by the operating team was torn. Of all gloves examined 22.6 per cent showed perforation following use in the operating room. This work emphasizes the fact that simple washing of the gloved hand would not remove the danger of contaminating the surgical field with talcum powder. A relatively large amount of powder remains inside the glove and can easily be spilt into the wound when a glove is perforated.

German[6] in a subsequent report reviewed 20 cases in which he found upon microscopic examination large numbers of talc crystals within the tissue. He required 3 or more crystals per microscopic field before he would consider talc as a causative agent. From his animal experiments in the production of talc granuloma, he states that concomitant tissue trauma is necessary in the region of talc implantation for the production of granuloma.

Wells[22] in 1944 noted a number of cases in which talc granuloma had caused a failure of surgical wound healing.

A number of authors have thus recognized the dangers in the use of talcum powder. Seelig, Verda and Kidd[17] in 1943 were the first to offer a substitute for this offending material. They suggested the use of potassium bitartrate powder which they pointed out caused no such tissue reaction as did talc, and was relatively resistant to autoclaving. They also called attention to the bacteriostatic properties of this powder. Subsequent to their report, this material has been adopted by a number of surgeons throughout the country with varying success. The greatest drawback to the use of potassium bitartrate is that if autoclaved for longer than 20 minutes it tends to caramelize, making rubber gloves sticky as well as decreasing their elasticity.

Seelig[18, 19, 20] in a series of three papers in 1944 and the year following,

re-emphasized the dangers of talcum powder in the operating room, and offered another more desirable substitute in the form of a specially treated starch powder. It was felt that this new agent once available would replace both talcum powder and potassium bitartrate.

Recently Lichtman[8, 9] *et al.* have published two papers reviewing the entire problem very thoroughly. They present a large series of lesions in which the reaction to talcum was considered to be an etiologic factor, and discuss the microscopic similarity between the talcum lesions, sarcoid and tuberculosis. They also point out the similarity between talcum powder granuloma and some of the manifestations of regional enteritis.

During recent years surgical specimens showing chronic inflammatory lesions have been examined by us with crossed Nicol prisms, and many clinically unsuspected cases of talcum powder reaction have been identified. The prevalence of these lesions and their varied clinical manifestations prompted us to review the surgical pathologic material at the Barnes Hospital in an effort to correlate our experience with this condition. Many cases coming to re-operation prior to the recognition of the propensities of talcum powder to cause such granuloma had been incorrectly diagnosed, only to be discovered upon re-examination in the light of later knowledge. It is interesting to note that in several cases the pathologist remarked upon the reaction as being "similar to one around a foreign body," but talc was not incriminated until after Antopol's article in 1933.

The fact that talc crystals are found in a microscopic section does not necessarily mean that they underly the essential nature of the pathologic lesion. A high percentage of cases at re-operation show evidence of the presence of a few talc crystals but in most cases they are merely an incidental finding. Crystals around the periphery of the section are felt to be contaminants, probably from the examining pathologist's glove. For this reason precipitated calcium carbonate is used as a dusting powder in the surgical pathologic laboratory, it being adequate as a powder and impossible to confuse with talc crystals because of the inability of chalk to rotate polarized light.

We have tried assiduously to avoid indicting talcum powder as the primary etiologic agent in a case until certain criteria have been fulfilled. These are:

1. The finding of doubly refractile crystals in the microscopic section. These crystals must be within the body of the material sectioned.
2. The crystals must have the morphology of talc, as differentiated from lint, fibers of cotton, silk, cholesterol crystals, etc.
3. A typical foreign body reaction must be present immediately around these crystals, which includes the presence of multinucleated giant cells, round cells, and a varying amount of vascular fibrous connective tissue.
4. Clinical interpretation consistent with talcum powder granuloma. This includes a previous operation at the site of granuloma formation, and no other evident source of origin to explain the condition.

Using these criteria, 37 cases have been identified in which a reaction to

TABLE I

Case No.	Original Operation	Time Between Orig. Op. and Appearance of Symptoms	Chief Complaint	No. of Operations Subsequent	Operations Performed	Duration of Symptoms	Died
1.	Appendectomy	3 wks.	Intestinal obstruction	1	Lysis adhesions	6 wks.	
2.	Appendectomy	5 days	Abdominal sinus	5	I&D. Curettings. lap.	2 yrs. +	
3.	Suprabic prostatectomy	0	Abdominal sinus	2	Curettings	2 mos.	
4.	Removal of wart	0	Scar on face	8	Plastic to face	2 yrs. +	
5.	Appendectomy	5 days	Abdominal sinus	2	Excision sinus	17 mos. +	
6.	Cholecystectomy	0	Abdominal sinus	2	Lap. I & D.	8 mos.	
7.	Salpingectomy, oophorectomy	5 days	Urinary and fecal fistula	3	Closure fistulae	10 yrs.	
8.	Myomectomy, appendectomy	0	Abdominal sinus	2	Excision sinus, I&D.	10 mos. +	
9.	Appendectomy	0	Abdominal sinus	1	Excision sinus	2 mos.	
10.	Appendectomy, oophorectomy	9½ yrs. 6 days	Fecal fistula	2	Closure fistula	6 mos.	
11.	Laparotomy	0	Abdominal sinus	2	Lysis adhesions	6 mos.	
12.	Appendectomy	5 mos.	Mass in RLQ	1	I & D. abscess	1 mo.	
13.	Appendectomy	0	Fecal fistula	4	I&D, excision sinus, resection	1 yr.	
14.	Appendectomy	3 wks.	Abdominal sinus	3	Excision sinus	2 yrs.	
15.	Herniorraphy	0	Mass, sinus	2	I & D.	3 yrs.	
16.	Appendectomy	0	Fecal fistula	3	Closure fistula	21 yrs.	
17.	Laparotomy	3 mos.	Intestinal obstruction	6	Lysis adhesions, colostomy, resection ileum	3 yrs.	
18.	Appendectomy	3 mos.	Abdominal sinus	2	Excision sinus	6 mos.	
19.	Appendectomy	14 mos.	Abdominal sinus	4	I&D. curettings	2 yrs.	
20.	Appendectomy	0	Abdominal sinus	4	Laparotomies, exploration	26 mos.	
21.	Nephrectomy	2 mos.	Lumbar sinus	1	Excision sinus	2 yrs.	
22.	Appendectomy	7 mos.	Mass in RLQ	2	I & D.	20 mos. +	
23.	Appendectomy	0	Abdominal sinus	3	Lysis adhesions, I&D.	7 mos. +	
24.	Appendectomy	0	Intestinal obstruction	5	Lysis adhesions, ilectomy	3 yrs. +	
25.	Gastrectomy	1 mo.	Obstruction anastomosis	5	Esophagoplasty, lysis adhesions	6 mos.	
26.	Abdominal hysterectomy	1 wk.	Fecal fistula	2	Ileocecostomy, closure	3 mos.	X
27.	Laminectomy	2 mos.	Sinus	1	Excision sinus	6 mos.	
28.	Laparotomy	1 yr.	Intestinal obstruction	3	Ileostomy, resection		
29.	Laparotomy	1 wk.	Abdominal sinus	3	I & D.	6 mos.	
30.	Appendectomy	2 mos.	Intestinal obstruction	3	Lysis adhesions, resections	6 mos.	X
31.	Thoracotomy	0	Chest sinus	2	Curetting sinus	10 mos.	
32.	Appendectomy	10 yrs.	Intestinal obstruction	3	Lysis adhesions, enterostomy	11 yrs.	
33.	Abdominoperineal resection	2 yrs.	Stenosis colostomy	1	Enlargement colostomy stoma	6 mos.	
34.	Laminectomy	0	Pain in leg	1	Laminectomy excision granuloma	13 mos.	
35.	Abdominoperineal resection		Stenosis colostomy	1	Enlargement colostomy stoma		
36.	Cholecystectomy	0	Intestinal obstruction	3	Lysis adhesions	2 yrs.	
37.	I&D. perineal abscess	0	Perineal sinus	2	Excision perineal sinus	2 mos.	

talcum powder produced the essential lesion. Table I summarizes the important data of these cases.

Not included in this series is a considerably larger group in which all of the criteria mentioned above could not be satisfied. In this latter group the majority of the patients had undergone previous laparotomies with resulting dense diffuse adhesions. As can be noted in the photomicrographs, a minute amount of talc is capable of producing a wide fibrotic reaction. The cellular reaction in these cases was identical with that resulting from talc, but because sufficient amount of talc could not be identified, we have not felt justified in including them in the present series. We call attention to them, however, to stress the point that the talc reaction in our opinion plays a prominent role in many instances in the formation of that type of dense stenosing fibrosis so often associated with postoperative symptoms.

The most striking fact concerning this group of postoperative patients is the diversity of the clinical syndromes that they represent. The most common finding is that of a surgical wound that failed to heal postoperatively. Twenty-three cases (62 per cent) had such a manifestation: 15 had a chronic abdominal sinus, 1 a lumbar sinus, 1 a sinus in the chest wall, and 1 a perineal sinus. A few of these were simple superficial wounds and were considered clinically to be stitch abscesses. Others extended deep into the peritoneal cavity.

Besides these sinuses, five fecal fistulas were found. Before including these cases, ample evidence of talc deep in the sinus wall was required, for many doubly refractile vegetable bodies could pass into such a fistulous tract from the lumen of the intestine. As in Lichtman's series[8] many of these cases with fecal fistulae had been thought clinically to have regional enteritis.

Table II shows the frequency of the various clinical complaints.

TABLE II

CLINICAL COMPLAINTS IN 37 PATIENTS WITH POSTOPERATIVE TALCUM POWDER GRANULOMA

Sinus	18
Abdominal sinus	15
Lumbar sinus	1
Chest sinus	1
Perineal sinus	1
Fecal fistula	5
Intestinal obstruction	7
Tumor mass	3
Neurologic signs	2
Stenosis	2

Most of the patients in this series had many previous operative procedures before being seen in this hospital. Eight patients (22 per cent) had four or more operations. The average patient had 2.5 operations with no assurance that more procedures would not be required after discharge. In two patients further surgery is known to have been performed at other hospitals when emergency procedures were necessary.

The type of operation performed in treating these complaints were varied.

Seventeen patients had closure or attempted closure of a chronically draining sinus. Many of these patients required multiple operations. Lysis of postoperative intestinal adhesions was carried out in seven cases, and a like number required bowel resection. Incision and drainage, with curettage of sinuses was performed in 21 cases.

The condition most often confused with talc granuloma clinically in this series was tuberculosis. This was due to the chronicity of the signs and symptoms and to the similarity in the gross between the granulomatous lesions. Non-caseous tuberculosis was a repeated suggestion in the clinical histories, and gross examination often lent weight to the diagnosis. The microscopic picture was of course always slightly atypical of tuberculous infection.

As previously noted, regional enteritis was often suggested when small bowel symptoms predominated.

Talc granuloma is a chronic condition. In this series, symptoms ranged from a few months to 21 years. During this time there were long silent periods in which no evidence of foreign body was seen. Then without obvious stimulus there were symptoms of irritation. Although a few cases had their first symptoms occur in a matter of months after operation, most had some evidence of foreign body reaction during their immediate postoperative hospital stay. Those cases with obstructing intestinal adhesive bands seemed to have late evidence of their talc reaction, perhaps because it required some time for the adhesions to form and become constrictive.

There were two deaths in this series.

The primary operations during which time talc was implanted represent procedures in all branches of surgery and its specialties. The most common operation responsible for talc spillage was appendectomy (49 per cent), followed by laparotomy for unknown procedures (11 per cent). Gynecologic operations accounted for 11 per cent of the cases, genitourinary, orthopedic, plastic, thoracic and neurosurgical procedures each were responsible for at least one example of talc spillage and subsequent reaction.

The danger of this silicotic reaction, therefore, is universal. In some areas small granulomas may cause fewer symptoms than others. This proliferative process once present usually persists for years. The part it plays in the production of postoperative abdominal adhesions has been tragic and apparent. The damage in other surgical procedures such as craniotomy, while present, has been less obvious.

PATHOLOGY

Upon gross examination talc granulomas are not pathognomonic. In cases where a mass was observed, the operative notes almost invariably mention the hard consistency and pearly white or grey color of the tumor. In many cases biopsy of the area was made upon laparotomy because of the dense consistency of the area, which suggested malignancy. When small multiple, discrete areas of reaction were seen at operation, the surgeon's note often mentions the resemblance to miliary tubercle formation. Adhesive bands within the peritoneum were noteworthy because of their dense inelastic consistency and

their vascularity. The pathologist usually described the smaller lesions as feeling shotty when rolled between the fingers.

The largest granuloma in this series was a sausage shaped mass involving the transverse colon, measuring 14 cm. in length and 8 cm. in width. (Case No. 30.) Most of the granulomas, however, were small nodules measuring about 1 cm. in diameter.

Microscopically talc granuloma fits in with those agents that upon introduction into the body cause a foreign body reaction of the proliferative type.[10] Pulmonary silicosis has been widely studied, and talc (Magnesium Silicate) reaction is merely a localized form of this same condition.

Talc crystals are seen microscopically to be surrounded by masses of fibrous tissue in which there is excessive collagen production along with inflammatory cells. Individual talc crystals are seen to be the nidus of the inflammatory reaction, which has a peculiarly wild and unoriented appearance. Connective tissue strands are mixed in whorls and cross currents as they envelop the irritating talc particles. The cellular response consists of foreign body giant cells which surround (and in the case of small crystals also ingest) the talc particles. No evidence of destruction of these non-absorbable particles is seen so that the reaction by no means resolves the condition. The multinucleated cells in some cases reach tremendous proportions, generally with a clear cytoplasm in which numbers of small nuclei are eccentrically clustered. Small round cells are typically in evidence. No caseation is ever seen.

The microscopic similarity to a tubercle is evident, for a focus of inflammatory reaction is surrounded by lymphocytes, giant cells, and a proliferative connective tissue response. Identification of talc crystals in the center of the lesions is of course the point of differentiation. This can be performed on routine examination merely by using a strip of polaroid material between the light source and the microscopic slide, and another such polarizing strip between the slide and the eye arranged so as to darken all but birefringent particles.

Foreign body reactions from other materials are often similar microscopically to that due to talcum powder crystals. The reaction to suture material is of interest in this respect. Strands of cotton or silk are themselves slightly birefringement. It was noticed in several cases, however, that strands of such sutures were surrounded by a halo of birefringent particles that did not appear to be silk or cotton fibers, but rather to be of the nature of talcum powder crystals. For this reason, several sutures were mounted on a slide and examined with polarized light. It was found that sutures that were new and dry showed none of these birefringent particles. Suture material from the same source was then wet in water and run through a hand that had been dusted with talcum powder. The particles of talc obviously were transferred to the wet suture, and became adherent. It is possible, therefore, that much of the foreign body reaction ascribed to suture material may actually be due to the tiny talc particles that are adherent to the thread.

From our own experience and from that of others where talcum powder

is used on the hands and gloves or where it is on the scrub nurse's table it is a source of danger. The deposition of a thin layer of talc on gauze sponges, packs, and on the instruments follows the all too frequent and vigorous powdering of the hands preparatory to donning gloves. With care this hazard may be lowered, but even the utilization of utmost care cannot completely exclude the possibility of occasional accidental contamination.

The ability of talc to spread throughout a room can easily be demonstrated by placing a dark piece of paper or a book on one side of the room, then carefully powdering the hands on the opposite side of the room. In a matter of a few minutes a thin layer of talc will be seen settling on the darkened surface.

It would seem to us that the best answer to the problem is either the use of wet gloves or the substitution of an innocuous dusting powder. As previously mentioned, potassium bitartrate has been used as such a substitute. More recently, starch treated with formaldehyde in order to prevent the formation of a gel upon autoclaving has been tried. Seelig has shown the lack of tissue reaction to this material in a series of elaborate animal experiments.

Variously treated starch compounds have been introduced into many animals (dogs, mice, rats, and guinea pigs). In no case does the powder elicit a granulomatous response. The innocuousness of starch in the tissue and the rapid rate of its dissolution is clearly evident when the powder is injected into the anterior chamber of a rabbit's eye. Examination of an animal four days after 2 mg. of formalized starch has been introduced into the right eye, and 2 mg. of talc had been injected into the anterior chamber of the left eye shows that starch has been absorbed, leaving no reaction. Severe fibrosis and tissue reaction is seen, on the other hand, in the talcum treated eye. The talc reaction subsequently caused blindness.

Unfortunately, however, very recent clinical experience has disclosed an unexpected difficulty. The formaldehyde starch is somewhat unstable, and seems to split up on ageing, liberating free aldehyde. This, of course, can act as an irritant to the hands of the surgeon. One corporation interested in developing the new powder seems to have used other aldehydes, and to have added magnesium carbonate to increase the "flow" of the powder. We have found previously that magnesium carbonate produces granulomata; moreover, the new aldehyde-starch powder has evoked hand irritation in one of our resident surgeons.

As a result of the more recent experience, we are still searching for an adequate substitute for talcum. More time must elapse before we can be sure that the aldehyde treated starch is completely innocuous to both the patient and the surgeon. In the meantime, as previously stated, potassium bitartrate, properly sterilized, can be used. Talcum must be banned from the field of surgery.

SUMMARY

1. Thirty-seven cases of postoperative complication due to talcum powder granuloma have been presented.

2. These cases represent a wide diversity of complications, ranging from simple wound abscesses to serious sequelae such as fecal fistulae and intestinal obstruction.

3. The clinical and pathologic nature of this condition has been discussed.

4. Emphasis has been placed upon the requirements of a suitable alternative dusting powder for use in the operating room.

5. Review of our experimental and clinical trials of formalized starch compounds as dusting agents in the operating room has been given.

6. The starch compounds as now produced are not completely stable, and must be further modified before we recommend their use.

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A SUSPENSION OPERATION FOR PROLAPSE OF THE RECTUM*

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THE MULTIPLICITY OF OPERATIONS which have been described for the treatment of complete prolapse of the rectum is evidence that an operation has not yet been designed which can be considered entirely satisfactory. The principles involved in the various operations described are, (1) excision of the protruding bowel, (2) operations to reduce the size of the anus and lower rectum, (3) plastic operations to restore or strengthen the pelvic floor, (4) abdominal suspension, fixation, or both, of the prolapsed bowel, and (5) obliteration of the deep cul-de-sac.

The fact that the etiology of complete rectal prolapse is not entirely clear may have influenced the trial of many operative procedures without sound fundamental reasons. Complete rectal prolapse is probably primarily the result of an abnormally loosely attached rectum, a developmental defect, as suggested by Pemberton and Stalker.[1] These authors compare prolapse of the rectum to prolapse of the sigmoid following sigmoidostomy, when the sigmoid has a long mesentery. In addition to the loosely attached rectum, a deep cul-de-sac is present, which, due to intra-abdominal pressure, acts as a potential hernia between the rectum and vagina in the female, or rectum and bladder in the male (Moschcowitz).[2] Graham[3] interprets the prolapse as a sliding hernia of the anterior rectal wall through the anal canal. The natural defect in the pelvic fascia which permits the passage of the rectum through the diaphragm is enlarged by the pressure against the anterior wall of the contents of the cul-de-sac of Douglas. With enlargement of the normal outlet of the rectum and defective and lengthened supporting structures of the rectum, prolapse may be expected to occur.

If the cause of rectal prolapse is due to an abnormally attached recto-sigmoid with a long mesentery, and a deep cul-de-sac predisposing to hernia, an operation designed to correct these two anomalies should produce a cure.

TECHNIC OF OPERATION (Figs. 1, 2, 3, 4)

Two strips of fascia 1 to 2 cm. wide and 10 to 12 cm. long are excised from the fascia lata.

A left paramedian incision is made from the pubes to a point about 2 cm. above the umbilicus. The patient is placed in the Trendelenberg position and the abdominal contents are packed away from the pelvis with warm moist pads. A tape is passed through the mesentery beneath the lower sigmoid for traction. Gentle traction will hold the prolapsed recto-sigmoid in normal position.

* Presented at the meeting of the American Surgical Association in Hot Springs, Virginia, March 25, 1947.

The fascia just above the promontory of the sacrum is exposed through an inverted T-shaped incision in the peritoneum. A strip of fascia is sutured to each side of the rectum with a double row of interrupted sutures of fine silk. The strip of fascia on the left is passed through a puncture wound made in the mesentery of the sigmoid. While the rectum is held suspended, the upper ends of the fascial strips are sutured to the dense fascia above the promontory of the sacrum. Interrupted silk sutures are used to attach both margins of the fascial strips to the fascia, a distance of at least 2 cm.

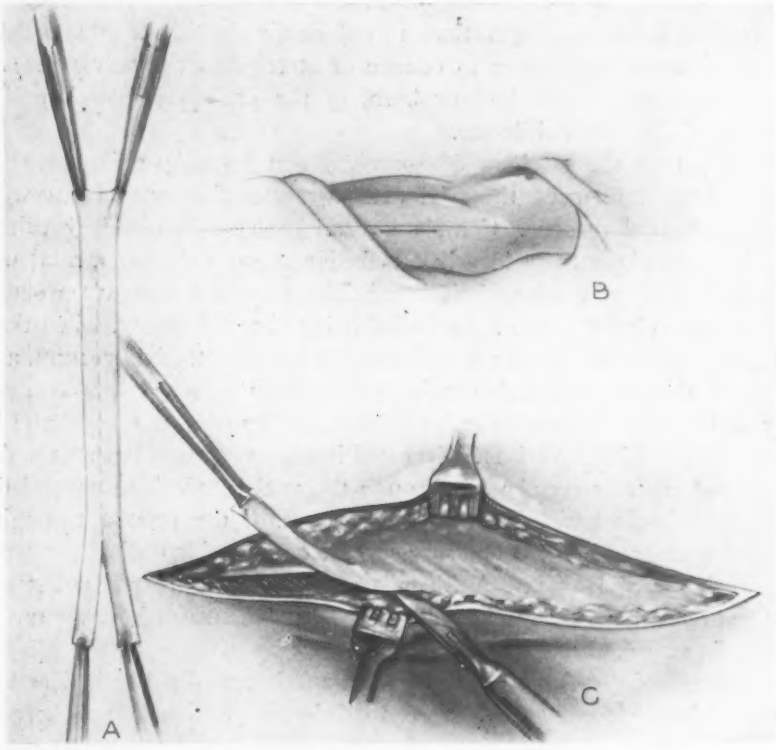

FIG. 1.—A, B, C. Technic of removal of fascial strips from fascia lata.

The cul-de-sac is completely obliterated by two or more rows of interrupted silk sutures placed across the pelvis. The peritoneum is sutured to the anterior wall of the rectum as each row of sutures is placed.

The pelvic operation is completed by suturing a fold of peritoneum to the rectum on each side to cover the fascial strips.

The abdominal and thigh wounds are closed with silk.

SUMMARY OF CASE REPORTS

Case 1.—F. H., a male, aged 36, was admitted to the University of Kansas Hospitals February 18, 1941. He dates his illness following a fall from a horse about five

years before admission. His rectum began to protrude with each bowel movement. Examination showed a complete rectal prolapse about 10 cm. in length. He was operated upon February 22, 1941. He made a good recovery and left the hospital on the 15th postoperative day. He last reported January 27, 1947. He has had no recurrence of the prolapse but has recently been constipated and complains of stomach trouble.

Case 2.—J. A., a male, aged 68, entered the hospital February 22, 1944. The first prolapse of the rectum occurred four weeks before admission. From the onset, the bowel

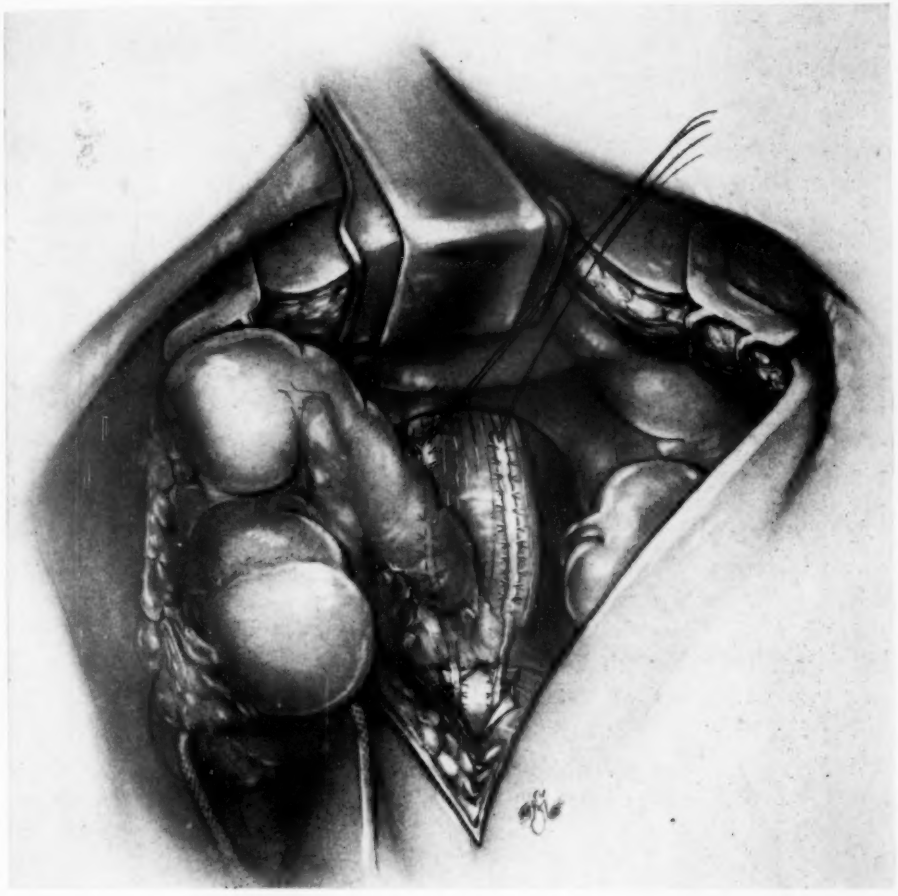

FIG. 2.—Fascial strips sutured to rectal wall and to fascia above the promontory of the sacrum. On the left the fascial strip is passed through the mesentery of the sigmoid.

prolapsed when his bowels moved and when standing. There had been some incontinence. This patient had a fracture of his spine one year before admission which resulted in spastic paraplegia. When straining the rectum protruded 5 to 10 cm. Since operation March 2, 1944, he has had no further evidence of prolapse. Because of his disability due to paraplegia he now spends much of his time in bed in a county institution. His condition was reported good on December 3, 1946.

Case 3.—J. J., a male, aged 33, entered the hospital November 12, 1945, complaining of rectal trouble. He had had a prolapse of the rectum at times since early childhood.

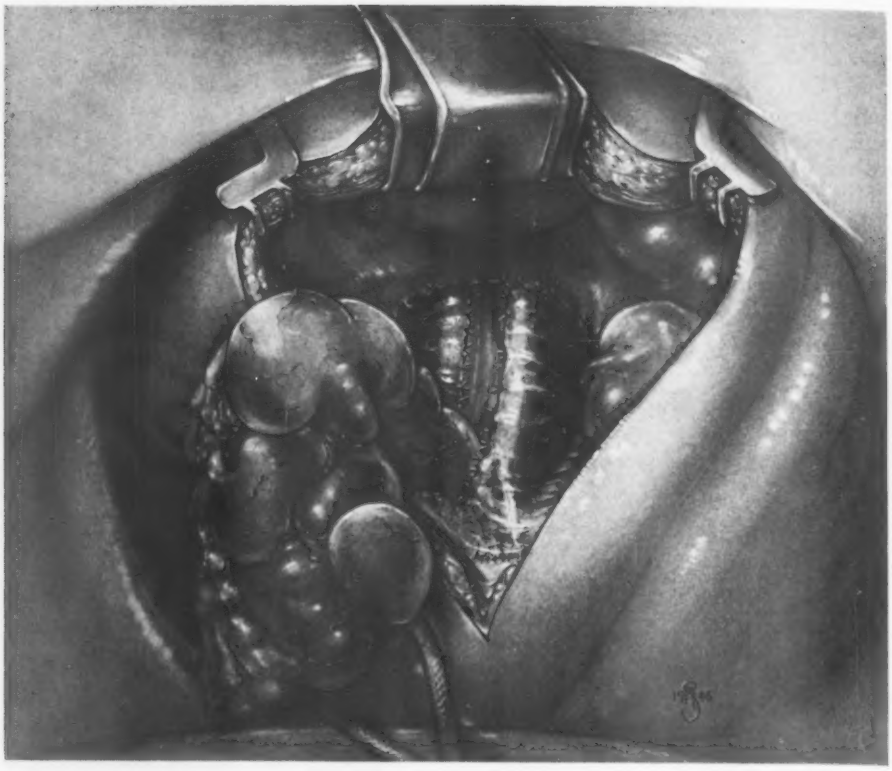

FIG. 3.—A fold of peritoneum has been sutured to the rectal wall on each side to cover the fascial strips. The cul-de-sac has been obliterated by rows of sutures placed transversely across the pelvis.

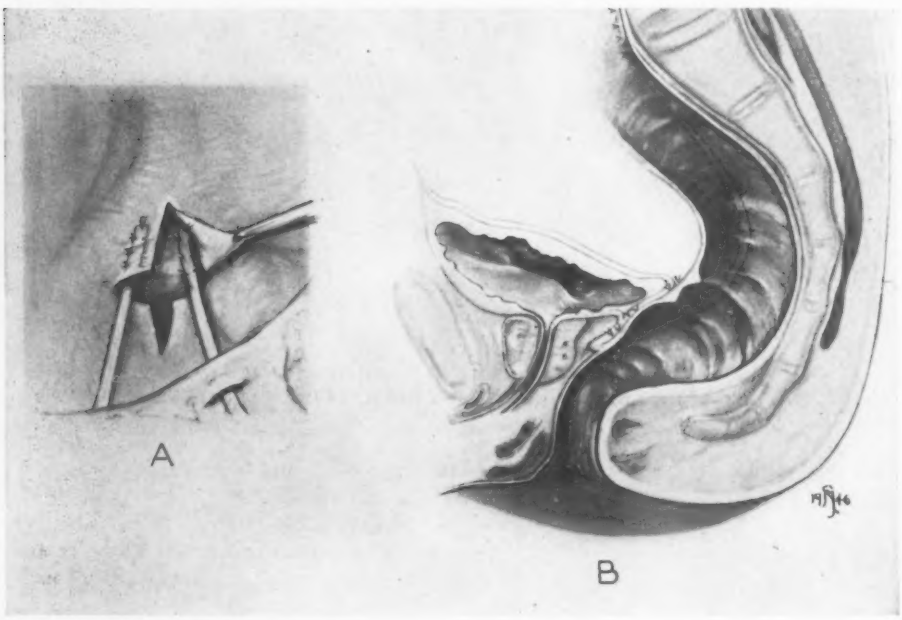

FIG. 4.—A. Detail of attachment of fascial strips to fascia above the promontory of the sacrum.
B. Lateral view of pelvis showing closure of cul-de-sac and location of fascial strip on wall of rectum.

About two years ago he had some type of rectal operation without benefit. The prolapse was greater after the operation and was associated with a dull pain in the rectal region. Examination showed a complete prolapse of the rectum which could be reduced manually. He was operated upon November 14, 1945. He reported on December 6, 1946, that he has no rectal trouble but does have some discomfort in the lumbar region.

Case 4.—Mrs. E. B., aged 66, was admitted to the Hospital on January 5, 1947. Prolapse of the rectum appeared about 15 months prior to admission. A rectal operation was done in February, 1946, which gave temporary relief. Asthma, which she has had several years, grew worse and she thinks persistent coughing may have influenced the return of the prolapse. For five or six months the prolapse grew worse until the rectum protruded constantly. She was a small emaciated woman weighing 84 pounds. The rectum protruded 10 to 12 cm. There was marked relaxation of the sphincters with almost complete incontinence. Following the operation on January 9, 1946, she made a good recovery and left the Hospital on the 12th postoperative day. On discharge she still had anal incontinence and some diarrhea. On March 15, 1947, her physician reported that there has been no recurrence of the prolapse and the sphincter tone has much improved. She has gained weight and is doing her housework.

TABLE I

Patient	Sex	Age	Date of Operation	Last Report	Result
F. H.	M	36	Feb. 22, 41	Jan. 27, 47	No recurrence of prolapse. Some constipation
J. A.	M	68	Mar. 2, 44	Dec. 3, 46	No recurrence of prolapse. Condition good
J. J.	M	33	Nov. 14, 45	Dec. 6, 46	No recurrence of prolapse. Some discomfort in back
E. B.	F	66	Jan. 7, 47	Mar. 15, 47	No recurrence of prolapse. Sphincter tone improving Doing own housework

RESULTS

The results in the four cases here recorded have been satisfactory to date (Table I). There has been no evidence of recurrence of the prolapse and the function of the rectum has been normal. The possibility of constriction or angulation of the lower sigmoid at the sacral promontory was considered but this has not happened. A barium enema has shown normal caliber of the rectosigmoid in two cases.

CONCLUSIONS

A suspension operation for complete prolapse of the rectum is described.

The steps in the operation suspend the rectosigmoid from the fascia above the promontory of the sacrum with fascial strips and obliterate the deep cul-de-sac of Douglas. It is believed that suspension of the loosely attached rectosigmoid directly prevents prolapse through the anus and obliteration of the deep cul-de-sac eliminates a potential hernia which is a contributing factor in rectal prolapse.

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Discussion.—Dr. Roscoe R. Graham, Toronto, Ont.: I should like to show four slides which have previously been presented before this Association. They confirm the hypothesis which Doctor Orr has enunciated, namely, that in massive rectal prolapse the apex of the prolapse is the pelvic cul-de-sac. In a patient with massive prolapse, the major portion of the visible bulge occurs at the expense of the anterior rectal wall as shown in Figure 1.

Fig. 1.—Patient in knee-chest position, with cork in lumen of rectum. Shows the prolapse at the expense of the anterior wall.

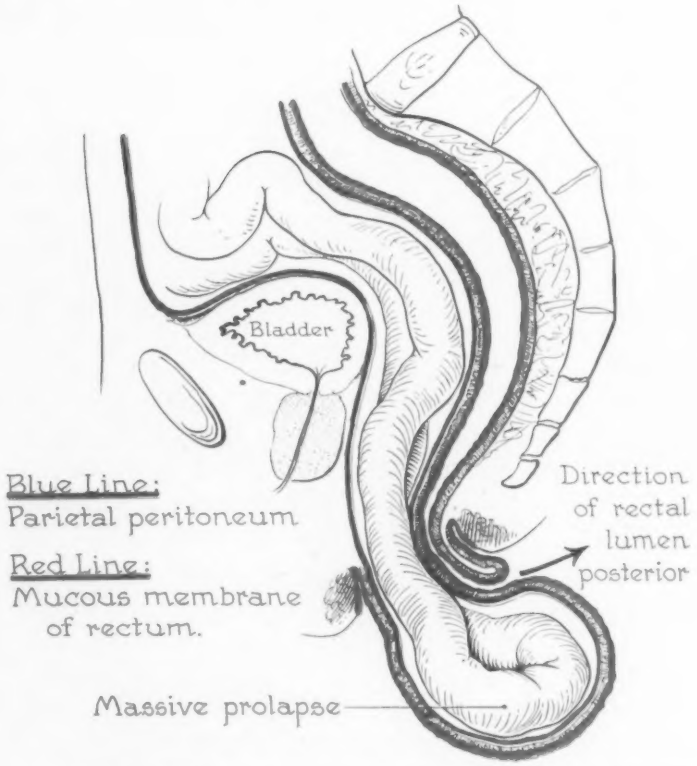

Fig. 2.—This shows very graphically the descent of the peritoneum at the expense of the anterior portion, and also demonstrates the eversion of the rectal mucosa through the sphincter.

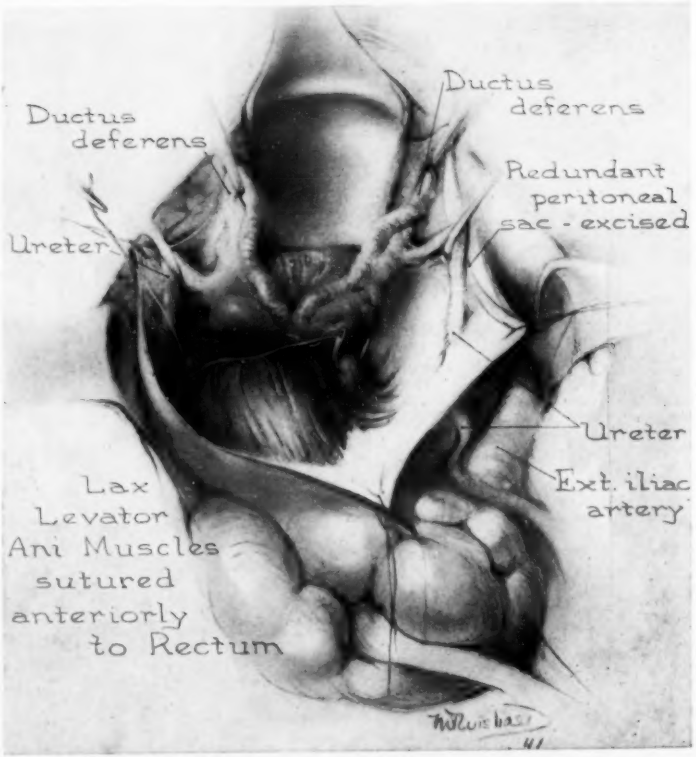

FIG. 3.—This shows the ureters isolated: the medial margins of the levator grasped with sutures to place the rectum back in the hollow of the sacrum.

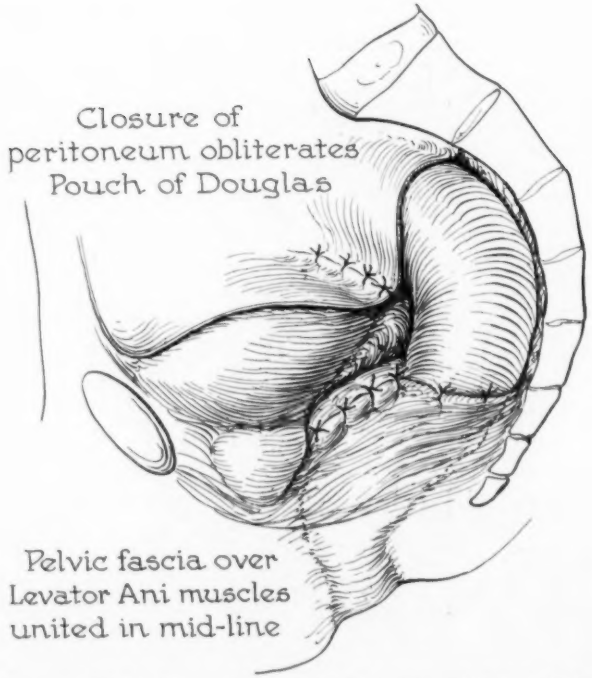

FIG. 4.—This shows the completed repair of the pelvic floor.

The cork is placed in the lumen of the bowel and, with the patient in the knee-chest position, the major portion of the bowel lies anteriorly. This is well illustrated in Figure II. The blue line illustrates the parietal peritoneum, which has slipped down between the two levator ani as it gradually deepens the cul-de-sac, and shows that the direction of the rectal lumen is definitely posterior. Our conception of this mechanism is that the prolapse occurs through the separation of the levator ani muscles.

In Figure III the peritoneal cul-de-sac has been drawn up into the abdomen and separated, the ureters isolated, and one can then visualize the median margins of the two levator muscles. They are then approximated by interrupted sutures and this changes the course of the rectum, in which it is placed back in the hollow of the sacrum, as seen in Figure IV. When this suture line had been completed it was no longer possible to invaginate the anterior rectal wall through the anal orifice. We had changed the direction of force exerted through increased intraperitoneal pressure.

We have had three cases in which this has been carried out with success, now sufficiently long to feel that it is permanent, and my colleagues have carried out three more, and in these there has been no recurrence.

LETTER TO THE EDITOR

Sir:

The article of Womack and Crider, "The Persistence of Symptoms Following Cholecystectomy," on page 31 in the July, 1947, number of the ANNALS OF SURGERY gives an ingenious and hitherto ignored reason for some of the residual symptoms in cholecystectomized patients. The abundance of autonomic nerve fibers and their involvement in scar-tissue was well demonstrated in their histologic sections.

For some time I have regarded and treated the so-called "adhesions" after laparotomy as being due to minor causalgic states in which partially damaged afferent nerve fibers set up reflex phenomena, just as they do in the extremities. It is furthermore fairly well established that visceral pain in the upper abdomen is mediated by the splanchnic nerves, in the case of the biliary tract in the right splanchnic. Doctor Walter and I have recently reported relief of intractable pain due to calcareous pancreatitis following splanchnic nerve section. We also observed a calcareous biliary tract disease exhibiting a painless course after splanchnic nerve section. Recently we have injected paravertebral procaine from D_6 to D_{10} on the right in a patient with persistent pain after cholecystectomy. She remained free of pain for six weeks after the first injection, and a second injection kept her symptom-free for another three weeks.

The purpose of this letter is to suggest that instead of excising multiple neuromata around the cystic and common duct and stripping them from their afferent fibers, one might consider temporary or permanent sympathetic interruption. One wonders whether the local excision of such trigger-zones, as Womack and Crider suggest, will not be followed at a later date by a recurrence of fibrosis and a regeneration of nerve-fibers. Certainly splanchnic nerve section is followed by a degeneration of fibers clear into the Pacinian bodies (Sheehan 1933).

Sincerely yours,

G. De Takats, M.D., Chicago.

EDITORIAL ADDRESS

Original typed manuscripts and illustrations submitted to this Journal should be forwarded prepaid, at the author's risk, to the Chairman of the Editorial Board of the ANNALS OF SURGERY.

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